

# A Study into the Cyclical Performance of the New Zealand Construction Industry



**Funded by BRANZ**  
from the Building Research Levy

November 2008



# **A Study into the Cyclical Performance of the New Zealand Construction Industry**



November 2008

CAENZ is an independent-think tank and research facilitator funded by grants and sponsorships. CAENZ's mission is to advance social progress and economic growth for New Zealand through broadening national understanding of emerging technologies and facilitating early adoption of advanced technology solutions.

[www.caenz.com](http://www.caenz.com)

**Report Authors:**

Neil Allan, Yun Yin and Eric Scheepbouwer

**Acknowledgements:**

CAENZ wishes to acknowledge the contributions made by Ian Page of BRANZ, Scott Caldwell of CAENZ and Hilary Lewis

**Approved by:**



RJ (George) Hooper

**Issued:** November 2008

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, transmitted, or otherwise disseminated, in any form or by any means, except for the purposes of research or private study, criticism or review, without the prior permission of the New Zealand Centre for Advanced Engineering.

**Copyright**

©2008 New Zealand Centre for Advanced Engineering

**Address for Correspondence**

New Zealand Centre for Advanced Engineering  
University of Canterbury Campus  
Private Bag 4800  
Christchurch 8140  
New Zealand

Phone: +64 3 364 2478 Fax: +63 3 364 2069 E-mail: [info@caenz.com](mailto:info@caenz.com)



# CONTENTS

<b>Executive Summary .....</b>	<b>5</b>
<b>Introduction to the Study .....</b>	<b>7</b>
Approach .....	7
Structure .....	7
<b>Part 1 – Interpreting Existing Knowledge .....</b>	<b>9</b>
Brief historical perspective of the NZ economy .....	9
Construction industry and the economy .....	10
The Think Big Era .....	10
The Construction Boom .....	11
The Recent Decades .....	12
So what is the problem? .....	13
What constitutes the construction industry? .....	15
Economic cycle theory .....	15
Complexity economics .....	17
Interconnection of cycles and influencing factors .....	19
Product lifecycle (PLC) of construction products .....	19
Local microeconomic cycles .....	20
Agricultural cycles .....	21
Related Industrial cycles .....	22
Indices/financial market cycles .....	22
Political cycles .....	22
Social/cultural/psychological cycles .....	22
Development pattern cycles .....	22
Environment cycles (Forrester Cycles) .....	23
Summary of key influencing cycles and stakeholders .....	23
Conclusion of review of existing knowledge .....	24
<b>Part 2 – Participative Phase .....</b>	<b>27</b>
Methodology .....	27
Interviews .....	28
Workshops .....	28
Soft Systems Methodology .....	28
Defining the system boundary .....	29
Outputs from one phase to the next .....	29
Intermediate Causal maps .....	32
System Dynamics models .....	33
The model for the private house building sector .....	34
The Industry Sector .....	34
The Inflation .....	34
The Population .....	34
The Market Demand .....	36
The National Account .....	36

Implications from dynamic modelling of the private housing market .....	36
The system dynamic model for infrastructure and public buildings sector .....	38
The Industry Sector .....	38
The National Account .....	38
The Population .....	38
Other Industries (Businesses) .....	38
Implications from modelling the infrastructure and public buildings sector .....	39
The model for the commercial building sector .....	40
The Industry Sector .....	40
Inflation and Costs .....	40
The National Account .....	40
Population .....	40
Implications from the modelling of the commercial sector .....	42
<b>Part 3 – Summary &amp; Recommendations .....</b>	<b>45</b>
 References .....	 49
Appendix 1: Segmentation of construction industry .....	53
Appendix 2: A System Model of the Construction Industry .....	54
Appendix 3: Different Theories of Business Cycles from Different Economic Schools .....	55
Appendix 4: Influencing Factor Model .....	57
Appendix 5 - Interview Questions .....	60
Appendix 6 - Transforming Concept Maps to Dynamic Models .....	61

# EXECUTIVE SUMMARY

This study introduces complexity economics and systems thinking as a methodology and approach to understanding why boom and bust cycles exist in the construction industry. System models have been developed to better understand, **not predict**, the dynamics of the multiple complex interactions, which range from hard economic data to people's irrational behaviour. During the study there has been extensive consultation with a broad cross-section of industry professionals and practitioners.

There is a broad appreciation of how the overall economic climate impacts the construction industry in New Zealand, but there is little uptake of the economic theories about boom and bust cycles by construction practitioners. There is broad agreement that cycles do exist and that they influence decision makers, but the cause of the cycles is uncertain and varies depending on the industry sector and perspective of the observer. Government spending and policy decisions are seen as a major influence for most participants in this study. Also, it is the rate of change, whether in boom or bust conditions, that cause the problem, not the fact that the industry has good years and bad years.

Generally it is accepted that a rapid upward phase of the cycle causes inflated prices and reduced competition due to full-order books;

whilst the downward phase leads to competitive cost cutting, reduced margins and pressure on quality. **It is this sort of negative self-fulfilling prophecy that should be challenged if the industry is to break free of the most negative aspects of boom and bust cycles.**

The study concludes that whilst external shocks will always impact the industry, much of the volatility is caused by internal system factors. Better communication within the supply chain, visibility of future orders, long range planning around resources, particularly skilled workers, and reducing delays in the approval and the procurement system can produce considerable improvements in performance and productivity.

The construction industry is an important bellwether and stimulus for the NZ economy. As a result, the construction industry is prone to manipulation by policy makers attempting to influence the domestic economy, often to the detriment of the industry itself. This duality of purpose causes increased uncertainty and volatility in the industry.

The key finding of the study is that the complexity and uncertainty that characterises the NZ construction industry demands changes to industry structures and strategic thinking that encourage collaborative learning processes.





# INTRODUCTION TO THE STUDY

The aim of this study is to establish and communicate a shared understanding of the key drivers in the boom/bust cycles of the construction industry in New Zealand. This shared understanding will allow for interventions and policy making to be more effective and responsive. It should also inform the industry about what it needs to know in terms of quantitative or qualitative data that would help further explain the interplay and interactions between the industry players, the environment, other industries and government.

Traditional econometric modelling, both macro & micro, of economic cycles is notoriously difficult and is dependant on high quality time series data. Where behaviours and perceptions are involved, the modelling quickly becomes too complex to be satisfactory.

## Approach

This study adopts a systems thinking philosophy, for two main reasons:

1. Systems approaches are seen by many leading thinkers (Peter Senge, Peter Checkland, David Elms, John Sterman, Eric Beinhocker) and research organizations (The Santa Fe Institute) as a more effective way to view complex, interconnected real world problems. Many complex, dynamic problems are difficult if not impossible to resolve using traditional approaches. Taking a new perspective on what is an old problem often provides real insights.
2. The construction industry is complex and fragmented, with many different bodies and differing objectives. Systems thinking strives to understand the key systemic behaviours and relationships rather than finding an optimal solution. In order to enable change aimed at controlling the negative impacts of cyclical behaviour in

the industry, it is first necessary to elicit a common understanding of the system structure.

## Report Structure

This study is split into three main sections:

1. Interpreting existing knowledge focusing on:
  - the history of New Zealand's economic system in relation to other leading economies and the influence of policy making on the construction industry;
  - understanding the stated problem in the context of New Zealand;
  - general theories of cyclical trends, including economic cycles;
  - systems thinking and the notion of complex adaptive systems as it relates to economics and industry behaviour;
  - particular subjects that apply to the international construction industry; and then
  - specific issues that relate to the New Zealand context.
2. A participative phase involving:
  - Interviews and workshops to capture key stakeholder concerns and perceptions of the problem, using soft systems approaches,
  - Mapping and integrating the stakeholder views,
  - Analysis of information to flesh out key dynamic patterns of the system,
  - Identification of any unique New Zealand system drivers that may influence policy or practice,
  - Workshops to feedback to industry and test the concepts.
3. Recommendations for implementation.



# PART 1: INTERPRETING EXISTING KNOWLEDGE

## Brief historical perspective of the New Zealand economy

Since its settlement in the early 19th century, New Zealand's economy has been based on its natural resources. Exports, dominated by pastoral products such as wool, meat, and dairy products, were sold predominantly to U.K. markets. Incomes rose rapidly, surpassed as late as 1960 by only the United States and Switzerland, prompting waves of migration.

The economy was also marked by a high degree of state intervention.

A cradle-to-grave welfare system was implemented, funded by taxation. Controls were imposed on labour and financial markets while state-ownership of industrial and commercial activities was prolific. The result of this extreme protectionism was gross inefficiency. The economy's profound structural weakness was exposed following a succession of shocks in the 1970s. The 1973-74 oil shock exerted huge pressure on macroeconomic balances, but more damaging was the accession of the United Kingdom to the European Community and its adoption of the Common Agricultural Policy, which restricted New Zealand's access to its then core export market.

Inflation became entrenched and New Zealand's budget balance moved deep into the red.

Increasing recourse was made to international debt markets to finance both the budget and current-account deficits. By 1984, the economy's chronic macroeconomic imbalances had prompted a collapse of confidence in foreign-exchange markets as New Zealand veered close to a Latin American-style debt collapse.

The Labour government that came to power in 1984 implemented one of the most radical reform programs adopted by an Organisation for Economic Co-operation and Development (OECD) nation. The New Zealand dollar was floated in March 1985, leaving its exchange rate to be determined by supply and demand, and the Reserve Bank granted greater autonomy from the government.

The impact of these macroeconomic and structural reforms was profound. The budget balance moved into large and recurring surpluses. Net external debt was eliminated, reversing New Zealand's former position as one of the largest borrowers in international debt markets.

From the late 1990s, the economy has demonstrated considerable resilience, weathering successive shocks buoyed by robust domestic demand. Through internal structural reforms, the economy appeared, until the latest oil price shocks, to have broken its boom-or-bust cycle moving to a trajectory of stable, sustainable growth. This has important implications for this

Statistic Description	NZ Value	OECD average	Ranks in OECD (out of 30)
Population	4.14 m	38.4 m	28 <sup>th</sup>
Population per km <sup>2</sup>	15	1,160	26 <sup>th</sup>
Employment Rate	75.3%	65.3%	5 <sup>th</sup>
Unemployment Rate	3.9%	6.9%	29 <sup>th</sup>
GDP (USD)	98.5 b	1096.5 b	27 <sup>th</sup>
GDP per capita (USD)	23,200	26,300	21 <sup>st</sup>
Growth Rate	4.8%	3.5%	7 <sup>th</sup>
CPI Inflation Rate	2.3%	2.4%	14 <sup>th</sup>
Price Level (OECD =100)	96	100	19 <sup>th</sup>
Government Spending (% of GDP)	34.1%	40.8%	29 <sup>th</sup>
Government Balance (% of GDP)	4.2%	-3.3%	2 <sup>nd</sup>

Table 1: Benchmarked economic statistics for NZ (Sampling time 2005)  
Source: Statistics New Zealand (<http://www2.stats.govt.net>)

study.

Table 1 provides some key economic statistics for New Zealand, relative to other OECD countries, to place its performance in an international context.

New Zealand GDP (Gross Domestic Product) is one tenth of the OECD average. However, taking population into account, the per capita GDP is just slightly below the OECD average. The employment rate is relatively high and the unemployment rate is quite low. The annual growth rate is in the top quartile and yet Consumer Price Index (CPI) inflation rate at 2.4% is close to the OECD average.

A recent OECD report (April 2007) warned that despite New Zealand having one of the most flexible and resilient economies in the OECD, large external deficit and very low household savings, combined with strong inflation pressures, are causing uncertain growth patterns. Moreover, despite economic growth since the early 1990s labour productivity growth has been lacklustre. The OECD report suggests the large swings in the New Zealand dollar and high interest rates are two of the key factors affecting productivity. Figure 1 clearly indicates the cyclical nature of the New Zealand dollar against a world index. Interestingly the Australian dollar shows a similar profile but not quite as volatile as the New Zealand currency.

According to Bollard & Hunt (2008) there have been a number of growth periods in New Zealand since the Second World War (see figure 2) some longer than others, suggesting a trend

towards more stability. They suggest that structural reforms and Reserve Bank policy changes are significant factors in the reduction of volatility in the economy. They do warn however, that the interconnectedness of global economies can mean that external shocks, such as the recent credit squeeze and oil price rises, can easily and rapidly influence New Zealand economic stability.

## Construction industry and the economy

Whilst there have been several growth periods followed by slowdowns in the economy as a whole, Bollard (1992) identified two significant boom periods for the construction industry; the “Think Big period” from 1977 until 1982 and the “Construction Boom” from 1984 until 1987. It can be argued that since 1992 there has been an additional boom cycle, until 2007, caused primarily by house demand and subsequent price rises, albeit with a slight downturn through the late 1990s. The longitudinal data of Building Consents Issued and Value of Work Put in Place, which are among the most representative indicators of the construction industry, is explored in Figure 3 to illustrate the historical performance of the industry. The trajectories of the two variables, value of work put in place and building consents issued, show a close correlation.

## The Think Big Era

The “Think Big programmes” were initiated by the government of the day, which invested

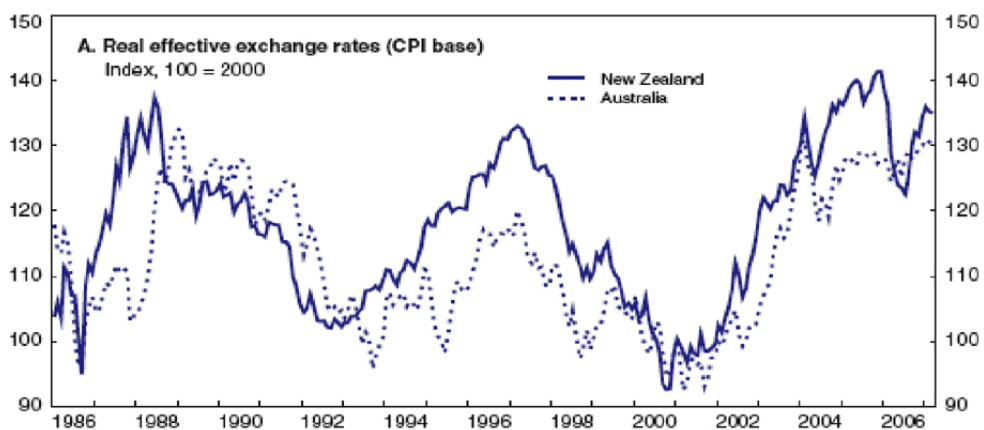


Figure 1: Exchange Rate Cycles

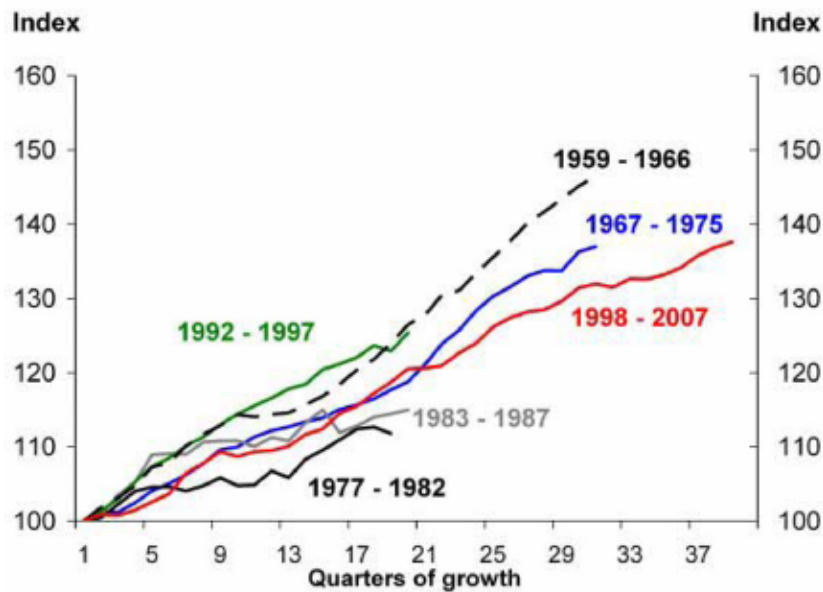


Figure 2: New Zealand's post war economic expansions

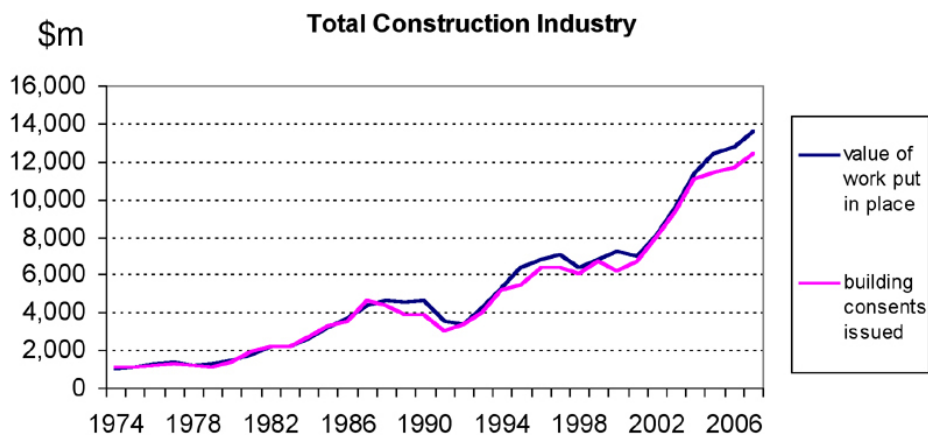


Figure 3: The performance of the total industry

around NZ\$6 billion per year, through several industry departments. Although the investment programmes created thousands of jobs and supported the local production and processing of energy, it did not bring the “further accelerator effect” (Bollard, 1992) that one might expect from such investment, and left New Zealand with over NZ\$28 billion of debt.

The boom cycle in the construction industry was short-lived. The external environment, in the form of the international oil situation, had a very strong influence on this cycle. The whole experience also had a long-lasting effect on decision makers and therefore on subsequent economic cycles. The “Think Big Era” influenced future policy makers away from too

much government involvement in a market dominated industry. As a result, we have a systemic loop set up of history influencing economic evolution and future decision making, which in turn then induces cyclical behaviour, which then impacts policy and influences policy makers. Indeed, it is striking how similar the current economic crisis is to the 1970s crisis. It is all too easy to blame external conditions in these situations instead of acknowledging the influence of the internal dynamics of the economic/political system.

## The Construction Boom

In the mid-1980s, the government liberalised the economy and deregulated the financial

sector. The subsequent growth of the financial sector coupled with government departmental restructuring increased demand for new office buildings.

There were far greater returns on investments in sectors such as construction when the real exchange rate rose (Grimmond, 1989/89-20 and Hunn, 1989). This was a signal to the market to invest in the construction sector, though the key factor that caused the boom was the deregulation policy of the government (Grimmond, 1989).

There then followed a significant downturn in 1987, as stock markets crashed around the world, resulting in rapid retrenchment and over supply of non-residential property in the early 1990s. The estimated amount of “unnecessary, premature or misdirected construction investment” (Bollard, 1992) was in total over NZ\$3 billion. The next two years saw a sharp decline in the number of people employed in the industry.

## The Recent Decades

In 1992, the New Zealand Institute of Economic Research forecasted that the contraction of the sector following the two boom periods had taken place and the trough of recession had passed. Despite small fluctuations in 1999 and 2001 there has been a steady growth in the construction sector since 1992 supported by overall building output figures (see Figure 4).

Evidence from the Reserve Bank (see Figure 5) suggests that construction output follows closely the national GDP cycles but swings more extremely.

This is confirmed by Hillebrant (2000), who shows international construction cycles have shown greater amplitudes than that of GDP and that the duration of construction cycles are longer than the economic cycles as well.

In macroeconomics, construction related indices are often used as the economy indicators. According to Mansfield (1988), construction related indicators are the major leading indicators of economic cycles. Orders for housing, building permits, housing prices, housing starts are all used as key leading indicators of the economy. Also, some indices in the construction industry, such as investment in building, plant construction and orders for engineering output are key lagging indicators of the economy. In New Zealand at the moment there is a strong correlation between residential construction prices and inflation (Page, 2005).

So we have the situation where the New Zealand economy is more volatile than its major benchmarking countries (Bollard & Hunt, 2008) and the construction industry is more volatile than other industrial sectors in New Zealand as a whole (Figure 5). The construction industry is more vulnerable to economic fluctuations than other industries, so consequently should be acutely aware of the causes

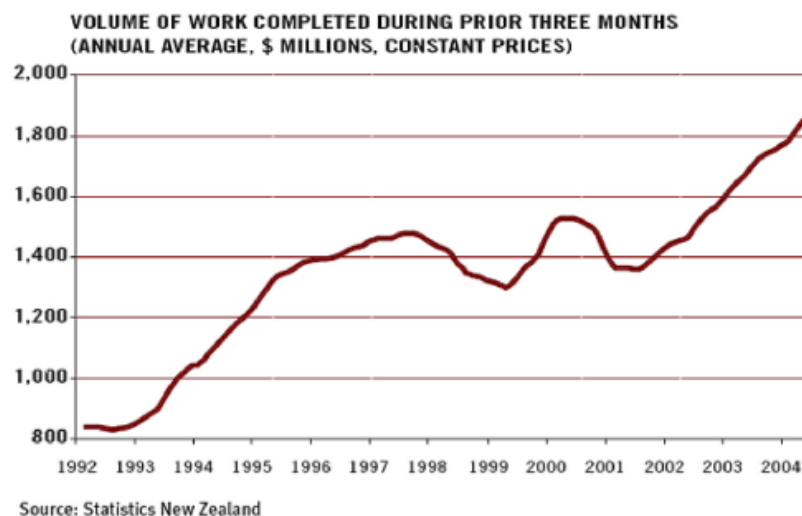


Figure 4: Volume of construction work completed 92-04



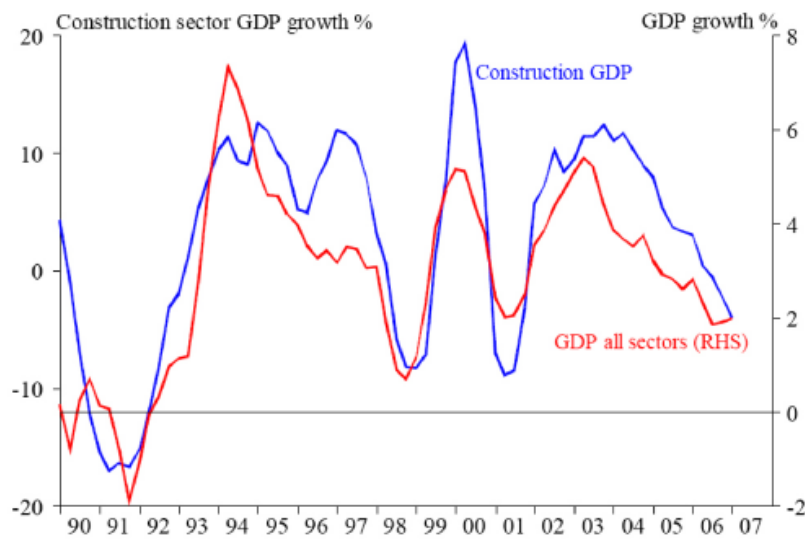


Figure 5: Construction GDP growth compared to national GDP growth. Source: Reserve Bank NZ

and the nature of the cycles in the economy and elsewhere.

Whilst the construction industry represents nearly 5% of total Gross Domestic Products (GDP) in New Zealand, it influences the economy in other ways. According to Nana (2003) and Toh (2004), the construction industry in New Zealand has a multiplier effect into other industries: for every \$1 of spending in the construction industry, \$1.168 is generated as output into the economy. Also, efficiency improvement gained in the construction industry enhances the overall performance of the New Zealand economy, in terms of its national competitiveness.

Construction is often seen as a vehicle in Keynesian economic policies through interest rates, public sector expenditure and the system of taxation. Also, government arranges for the construction of infrastructure and other goods regarded as public services, such as roads, water supply or schools. However, government is seen as handicapped by not having adequate methods for assessing the subsequent impact of changes on the industry, on society, or on the environment. Moreover, a research report commissioned by the Department of Trade & Industry (Dti) in the UK identified the changes and doubts over government decision making as the leading cause of uncertainty in the construction industry, (Allan & Davis 2006). Governments are often caught in a difficult

position where they are damned if they do make industry interventions and damned if they do not. A clear and consistent strategy regarding infrastructure and policies that influence building and construction would help reduce the impact of cycles but political cycles tend to work against such aims.

## So what is the problem?

Economic cycles are essentially over and under shoots of an optimal output level. At a national level this causes waste in the system and loss of productivity due to poor use of resources. For businesses there is added instability and uncertainty in planning, particularly human resources, which causes waste and increased costs. Figure 6 demonstrates an example of the periodic cycles in construction jobs.

Purchasers of construction work, including government, constantly seek best value for money and budget certainty from the construction industry. Boom cycles cause inflated prices and reduced competition due to full-order books, whilst recessionary trends lead to competitive cost cutting with reduced quality.

**This particular set of negative outcomes of boom bust cycles appears to be widely accepted across the construction industry.** It is one of those accepted perceptions that can initiate behaviours leading to a self-reinforcing loop, more commonly known as a self-fulfilling prophecy. Financers of construction lose money

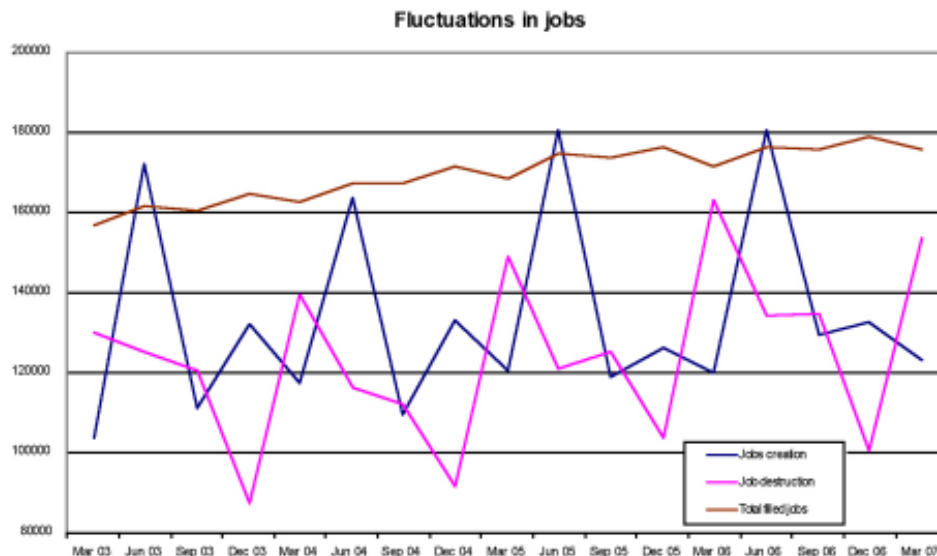


Figure 6: Plot of fluctuation in jobs over time in the construction industry.

Source: LEEDS database

– and confidence – in the industry resulting in capital being lost from the industry and a rise in the risk cost of finance.

Business/company managers are distracted from strategic issues in boom and bust phases. On the up phase of the cycle resource issues, spiralling costs, supervision and quality, tend to dominate. One manager admitted that this had resulted in less diligent pricing and scoping of future projects. On the downward phase of the cycle short-term work load issues, cash flow and redundancies tend to take attention away from future planning. Indeed one company director was so traumatised by the experience of laying-off staff in a downward cycle that he vowed never to expand his company beyond its current size. Clearly, management will always have distractions from strategic initiatives but it is the *pace* of growth or decline that particularly challenges management.

Labour planning, especially retention of trained staff, is particularly difficult in New Zealand with near full employment and net migration effects. In boom conditions skilled workers are attracted overseas to countries like Australia and UK who have closely coupled economic cycles, and in recession workers are also attracted overseas to seek better opportunities. The New Zealand construction industry has a labour turnover rate of over 20% on average over the past 20 years. These figures are comparable to the UK, which also shows

construction turnover being higher than other engineering sectors, such as manufacturing at 8% and electronics at 4%, (CIPD, 2007). It is considered likely that New Zealand follows a similar trend, although comparable data is not available. This in turn raises recruitment and training costs, though it is difficult to attribute all of this to boom and bust cycles.

Employees do face redundancy and uncertain futures as construction demand grows, peaks and falls, which in turn can have a significant impact on the wider economy and social well-being. In 2006, the construction industry directly employed 170,000 people or about 8% of the total workforce. Work by Nana (2003) on intra-industry multipliers indicates that at least the same number again are employed on off-site work in the supply chain.

Whilst the majority of participants in this study considered boom and bust cycles detrimental to business, there are some perceived benefits. Price increases, mainly due to supply and demand, during boom periods provide improved margins even though related input prices mitigate profits. On the downward phase businesses saw opportunities to stream-line operations, shed unproductive labour and generally become leaner.

History suggests that the construction industry is vulnerable to imbalances in the supply and demand relationship. Government interventions with multiple objectives and conflicting aims

can produce unintended consequences that exacerbate these imbalances. Moreover, when a tipping point is reached, the re-balance can take place suddenly, resulting in the construction sector (system) over-shooting or under delivering. As Bollard (1998) concludes, “the construction sector has a vital need for forward looking information to judge how far to commit itself and try to avoid the imbalances of supply and demand that have dogged its past”.

## What constitutes the construction industry?

In order to understand the behaviour of the construction industry in New Zealand, it is first necessary to describe its boundary, structure and purpose. Unfortunately, there is not a readily accepted definition of the construction industry or where its boundary lies. Some writers consider it as involving only site activity, whilst others include the planning and design functions and even extend it to cover the manufacturing and supply of material and components, finance of projects and management of existing construction items (Myers 2004). As we try to describe the relevant sub-systems or segments of the industry it becomes even more problematic as different groups have developed definitions depending on their perspective and needs.

Economic definitions are used by economists to relate data to theories for making predictions about the future performance and to make comparisons with other countries and industries. In economic terms ((Dornbusch 2003), (Mankiw 2003), and (Romer 1996)), the construction industry can be described as an economic system that transforms inputs into outputs to meet peoples’ needs.

Government uses definitions for the purpose of taxation and statistics. The New Zealand Standard Industrial Classifications (1993) classify the construction industry into two general divisions, construction and construction trade services, consisting of 7 groups and 21 classes. See Appendix 1 for more detail. Other governments use a similar taxonomy though (Bourn (2001) from the UK national audit suggests a more modern approach to classifying construction activities.

Commercial organizations have different approaches. The management consultancy firm Deloitte define the segments of the construction industry by the major activities (Deloitte 2006). Other consultants use supply chain definitions to look at value added activities. The basic idea of the supply chain approach is to formulate a logical network of related organizations by activities, information and resources that are involved in moving a product or service from supplier to customer. In this sense, energy, mining and logging industries are at the very beginning of the supply chain of construction industry. Different tiers of suppliers are involved to provide necessary materials to construction companies. Finance, consultancies and other service organisations also play significant roles adding value. Using the construction supply chain approach involves many different organisations and stakeholders. Furthermore, professional and trade bodies use their own definitions based on their membership interests and needs.

Clearly there are numerous techniques, approaches and taxonomies that could be used to define the construction industry and no one method can claim dominance. However, by taking a holistic, inclusive approach, a systems model of the construction industry can provide insights and a taxonomy that is meaningful from all perspectives. Appendix 2 provides details of the derivation of the model in Figure 7.

There are three major parts of the system model, the industry, the suppliers and the clients. Elements of the system model are connected by logical consequence of construction processes. Economics, value chain, supply chain approaches and, as well, government documents have been taken into consideration.

## Economic cycle theory

Periodic fluctuations in the economy have always attracted the attention of leading economists (some of whom have established considerable support for their ideas and some even have cycles named after them such as Joseph Schumpeter, Joseph Kitchen, Nobel Laureate Simon Kuznets and Nikolai Kondratiev). The classic theories developed from the various schools are reviewed in Appendix 3 and summarised here as key

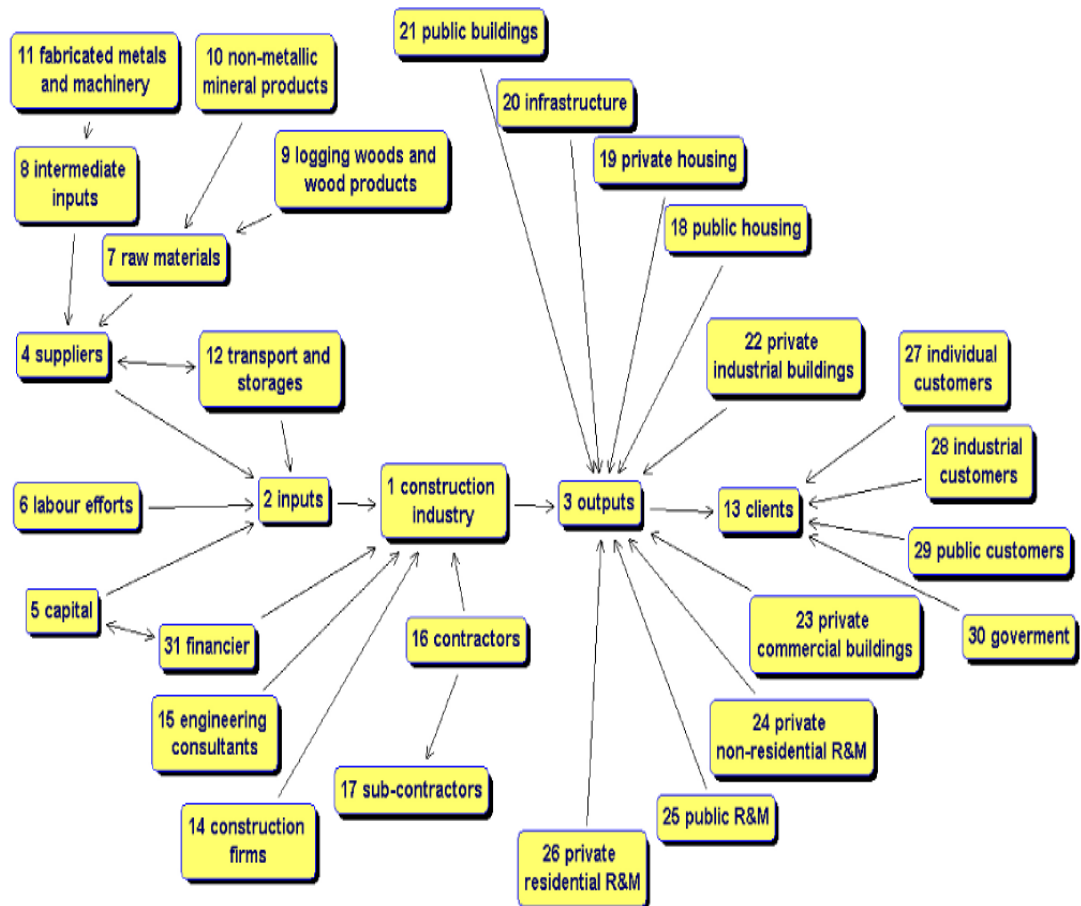


Figure 7: A model of the construction industry inflows and outflows

propositions:

1. Economic fluctuations exist with irregular intervals and are becoming fading phenomena in many countries.
2. Recessions are market adjustments to discordances in the economy which result from a failure of society to coordinate and are exacerbated by lags in the system.
3. Due to globalisation economic cycles are more interconnected with, and relative to, other economies.
4. Cyclical fluctuations in the economy can be controlled or postponed by governments using Keynesian type interventions.

Perhaps not surprisingly, there is no real agreement from economists on what causes economic cycles or their frequency. Indeed some argue that the reason why cycles are not regular is that the cycles do not exist and that fluctuations are caused by unpredicted shocks that do not ever repeat in the future. However, there are some common themes or drivers that emerge from the literature that seem to

influence the system we are interested in:

- The efficiency of resource allocation
- Demand change economics
- Supply change economics
- Technology change and disruption
- Market competition and free trade
- Labour supply and movement
- Wages and how this relates other factors such as inflation
- Interest rate and inflation
- Taxation both local and national
- Economies of scale
- Capability of government to control markets
- Price inflation or deflation (stickiness to real change)
- Investment failure
- Productivity changes
- Asymmetrical information
- Monetary and fiscal policies

- Externality effects
- Unforeseen shocks.

However, how these factors relate to and influence each other is uncertain and extremely complex, if not impossible in any meaningful way, to model.

## Complexity economics

According to Sterman (2005) and Beinhocker (2006), there are two recognised major shortcomings of economists' analysis of business cycles. Firstly, the theories are based on static patterns with historical data. The dynamics of a real economy system are often ignored or over simplified due to data availability and model restraints. The other major issue with economic theories is the oversimplification of human behaviour in the modelling.

Donaldson (1992) suggests that government policies affect the economy via influencing people's expectations. For instance, a minor rise in interest rate does not significantly affect people's daily income or expenditure, yet people might perceive a tightening monetary and fiscal policy and thus alter their behaviours in a disproportionate manner. Therefore, looking at the softer behavioural issues may benefit understanding the cyclic patterns.

By taking a systems approach it is clear we are dealing with a complex adaptive system whose behaviour is dynamic and non-linear. The major differences between traditional and complexity economics are provided below in Table 2, based on Beinhocker (2006).

Complex economic systems have several messages useful to this study. Firstly, interde-

	Complexity Economics	Traditional Economics
Dynamic	Open, dynamic, non-linear systems, far from equilibrium	Closed, static, linear systems in equilibrium
Agents	Modelled individually; use inductive rules of thumb to make decisions; have incomplete information; are subject to errors and biases; learn to adapt over time; heterogeneous agents	Modelled collectively; use complex deductive calculations to make decisions; have complete information; make no errors and have no biases; have no need for learning or adaptation (are already perfect), mostly homogeneous agents
Networks	Explicitly model bi-lateral interactions between individual agents; networks of relationships change over time	Assume agents only interact indirectly through market mechanisms (e.g. auctions)
Emergence	No distinction between micro/macro economics; macro patterns are emergent result of micro level behaviours and interactions.	Micro-and macroeconomics remain separate disciplines
Evolution	The evolutionary process of differentiation, selection and amplification provides the system with novelty and is responsible for its growth in order and complexity	No mechanism for endogenously creating novelty, or growth in order and complexity
Preferences	Formulation of preferences becomes central; individuals not necessarily selfish	Preferences given; Individuals selfish
Origins from Physical Sciences	Based on Biology (structure, pattern, self-organized, life cycle)	Based on 19th-century physics (equilibrium, stability, deterministic dynamics)
Elements	Patterns and Possibilities	Price and Quantity

Table 2: Complexity v traditional economics

pendence among various industry players can create multiple types of mutually dependant behaviour. As a result, industries and firms can become stuck in undesirable steady states that may include skewed policies or inferior technology choices. Secondly, the consequences of policies will depend critically on the nature of the interdependences. In particular, the effects of different policies may be highly nonlinear, rendering history a poor guide to evaluating future policy effectiveness.

Sterman (2000) goes into considerable detail about the benefits of dynamic modelling of economic cycles. Key systems ideas here are boundaries, positive and negative reinforcing loops, and delay. Sterman has had significant success in generating commodity cycles (copper, cattle, electricity etc.) that were statistically similar in important ways to real-world cycles. Figure 8a below shows plots of a real-world bull-whip effect in the giant US retailer Proctor & Gamble (Lee et al 1997).

Commodities that have supply, demand and stock relationships tend to oscillate due to human behaviour. However, the Proctor and Gamble supply chain is a relatively closed system compared with the construction industry. Therefore it is more difficult to

observe explicit macro-level bull-whip effects in the construction supply chain, which is not helped by the lack of comparable statistics and appropriate granularity of data. The best examples of the effect are shown in Figure 8b and 8c below of consents against expectations and intentions.

Figure 8b does show some increase in volatility and Figure 8c has a pronounced bull-whip effect from about 2002 onwards. Of course the overall economic cycle will impact demand, which is what the bull-whip is sensitive to, further masking the effect.

Sterman's research has also shown that people have a very difficult time mentally processing systems with complex feedback, with delays of varying lengths. Indeed, one of the most significant implications of Sterman's research is that the only way to mitigate the cycles is to change the structure of the system itself. For example by:

- Reducing the time delays in the system by avoiding over regulation, reducing consent approval times and speeding up the design and procurement process for large projects.
- Having a more modular flexibility, such as developing smaller interrelated projects

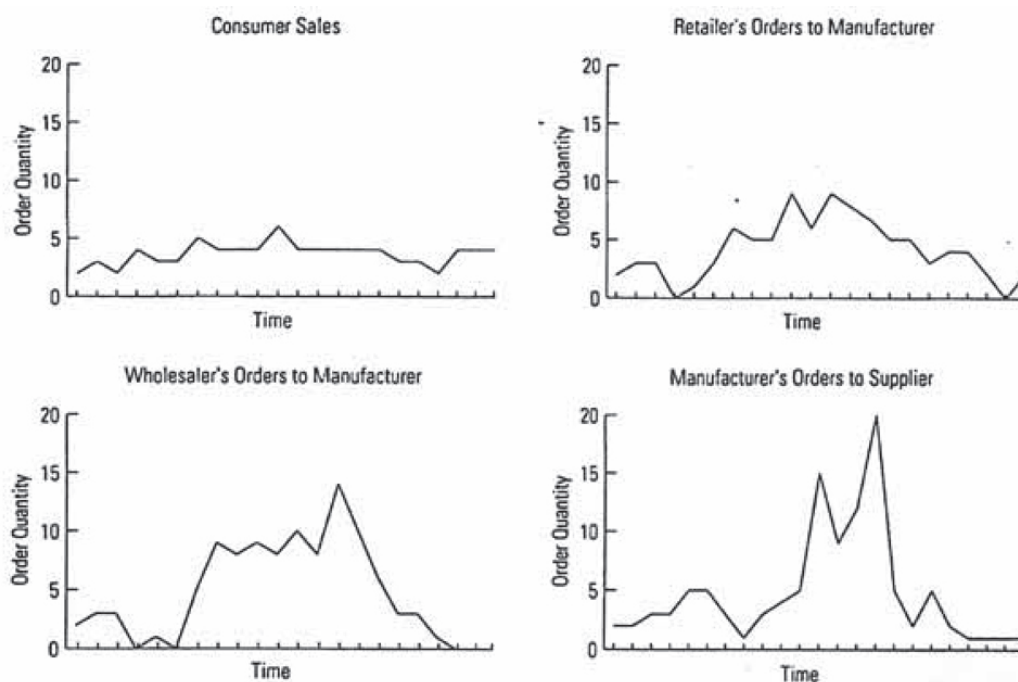


Figure 8a: Depicts bull-whip effect in a study on Proctor & Gamble, 1997  
Source: Sloan Management Review



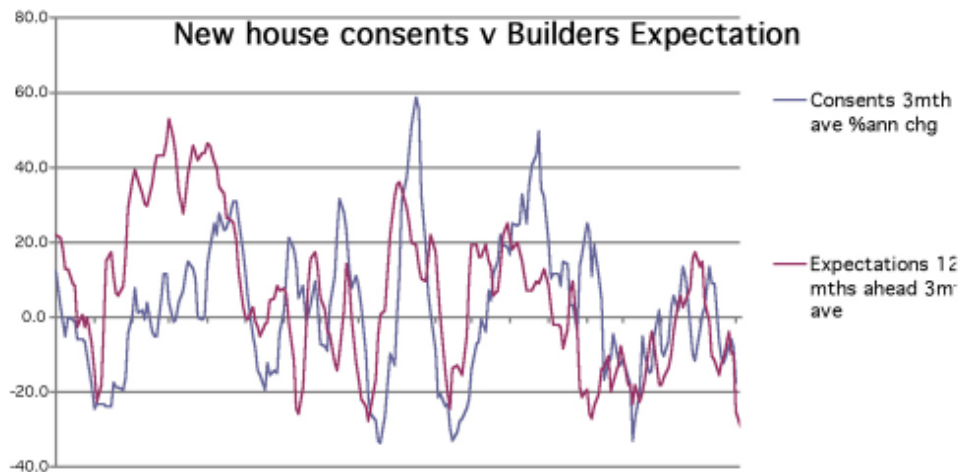


Figure 8b: Building consents against builder's expectation in the private housing market (3-month average)

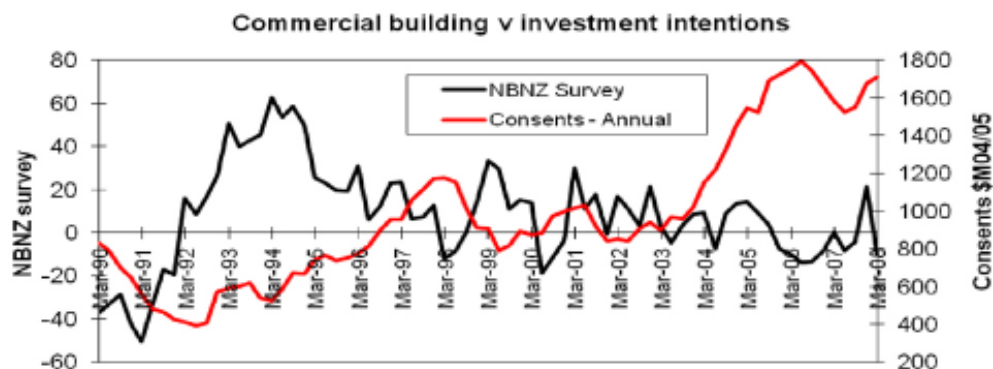


Figure 8c: Commercial building consents against investment intentions (3 month average of NBZ confidence survey)

rather than large inflexible ones and designing using standard modular components.

- Getting more forward and accurate visibility on customer orders. This approach has been quite successful when implemented in the highways sector.
- Increasing the transparency of how much capacity is actually available in the industry versus how much is utilised in existing construction.
- Understanding the impact of the flexibility that exists within the construction industry through staff working more or less time, shifting temporarily into other sectors and going overseas.

### Interconnection of cycles and influencing factors

There appear to be numerous cycles impacting

the construction industry; some of small amplitude and period, others resembling long period waves. The challenge is to understand how these interrelate and when peaks concur. One way to represent the interconnectivity of the most relevant cycles in the construction industry is by the nested systems diagram show in Figure 9.

Systems theory suggests that the interfaces or boundary between these sub-systems are important, and are likely to be where key issues emerge and where communication is weakest.

### Product lifecycle (PLC) of construction products

Product lifecycles are widely used as a strategic technique to help capture a deeper understanding of the product demand and evolution

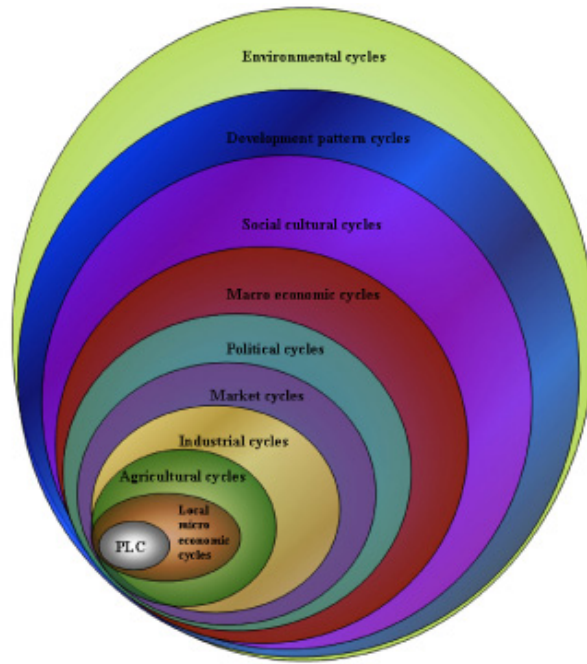


Figure 9: Nested diagram of the cycles impacting the construction industry

over time. In outline, the lifecycle of a product or service commonly follows key identifiable phases (see Figure 10):

- The *beginning*; signalled by innovation and introduction to the market.
- The *growth* phase; typified by rapid development, high profitability and emergence of new competition.
- The *maturity* phase; occurs as the growth slows and the market becomes more stable, often associated with competitor consolidation.
- Finally the *decline*; caused by market shrinking and company failure, with weak competitors exiting the market. Sometimes innovation and product modification can reinvigorate the market before it goes into decline, which extends the life of the product or service.

The construction industry has two additional and distinct sub-phases within a normal lifecycle curve. The first can be described as the project lifecycle, which starts from initiating a construction plan and ends at handing it over to the users. A large proportion of the construction industry is involved in this cycle. All interested parties are gathered and organized together to deliver the construction product to meet a specific market or client

demand.

The second life-cycle can be described as repairing and maintenance (R&M). This phase usually starts well beyond the normal project completion phase and continues throughout the rest of the lifespan of the construction product, rising to a peak as the product reaches the end of its utility. This cycle is sometimes referred to as the 'bathtub' curve, and the duration of the cycle is primarily determined by a cost/benefit analysis associated with the original product purpose and investment in durability. Non-financial measures, such as conservation issues, can play a significant role in this determination.

In summary, the product cycles in the construction industry may be affected by the demands for new construction products and the demands for the R&M of existing products, with a complex lagged relationship between the two.

### Local microeconomic cycles

Due to the characteristics of the construction industry, the local economy can influence the construction industry significantly. The construction industry relies heavily on the local economy for providing labour and markets. If the local market is booming, there will be more capital investment which stimulates the

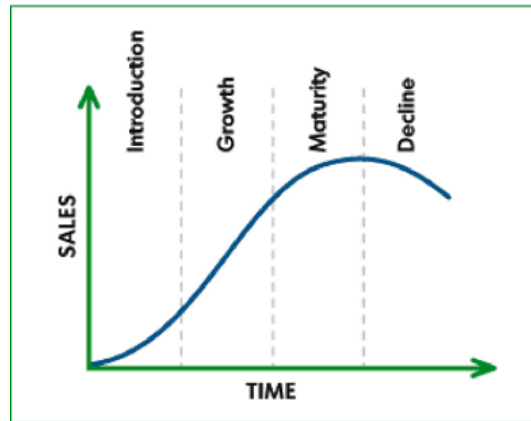


Figure 10: Typical product life cycle

construction industry. Also, the construction multiplier effect means that a booming construction industry can have a very positive influence on the local economy. This mutual dependency can formulate a cycle which is out of step with the overall economy but still dependant on it.

### Agricultural cycles

Agricultural cycles might be the most well-known cycles in human history. The idea is based on the growth and harvest of a crop. A lunar cycle could accurately describe the cycle. However, agriculture is also affected by environmental changes and natural disasters, which disrupt the normal lunar cycle. This would cause fluctuations of outputs.

Construction industries are closely related to the agriculture industry in many aspects,

particularly in New Zealand, because:

1. Agriculture fluctuations affect the overall macroeconomic situation.
2. Many of the construction products directly serve the agriculture industries.
3. Agricultural fluctuations exert huge impacts on peoples' expectations.
4. People are generally optimistic at the beginning of an agricultural cycle (usually springtime) and willing to spend more, whereas people become more pessimistic towards the end of a cycle (harvest and onset of winter) and tend to be more prudent.

This is nicely represented by the graph in Figure 11, which shows a seasonal cyclical trend in earnings within the building construction industry, peaking in December and then dropping away in March.

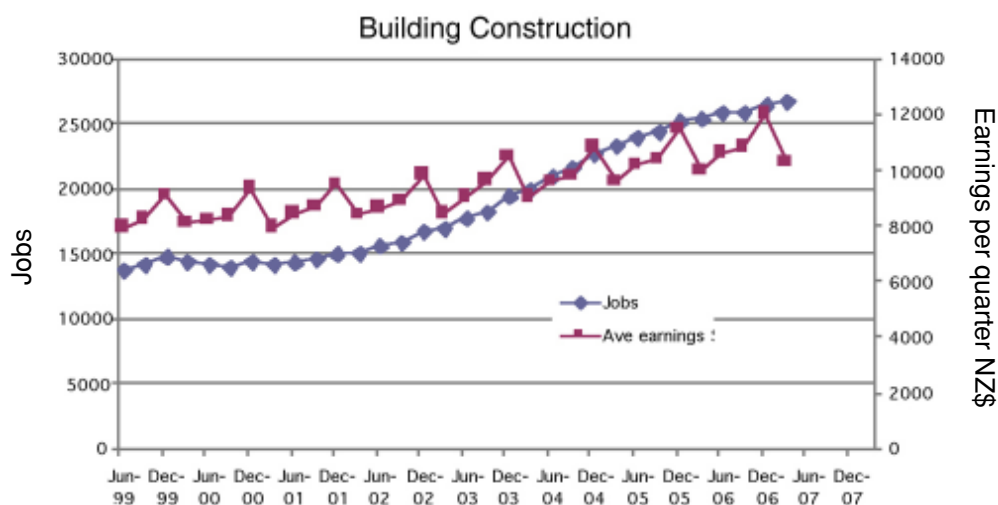


Figure 11: Annual cyclical trends in the building construction sector. Source: (LEEDS database)

### **Related Industrial cycles**

As mentioned earlier, the construction industry is closely related to other industrial and commercial sectors, in that they are major clients and supply most of the materials and products used in the construction industry. If fluctuations occur in either the supply or the demand side of the supply chain, the construction industry will be affected. Inventory cycles, Sterman (2006) or bull-whip effects are likely when there is stock holding in the supply chain such as steel, cement, bricks etc. Indeed the internal structure of the industry and its supply chain could be a major generator of boom and bust cycles, and certainly likely to make any cycles more pronounced.

### **Indices/financial market cycles**

Stock market indices clearly impact the market value of those companies that are publicly listed on stock exchanges and also those that invest heavily in the market. The companies issuing public shares tend to become the weatherglass of the industry. Their values determine the overall industry investment attractiveness.

Additionally, different indices influence mid and long-term confidence greatly. A booming market makes people confident or even overconfident when investing in fixed assets, such as housing and buildings, which would inject additional financial stimulus into the construction industry.

### **Political cycles**

According to Keynes, a totally free market might not be as desirable as a market with a certain degree of regulation and control. The Keynesian approach is widely adopted by governments, which become an increasingly important regulator and controller of the free market. Beyond conventional monetary and fiscal policies, in terms of interest and tax rates, additional market measures can be introduced such as infrastructure building, public purchasing, PPPs (Public Private Partnerships) and PFIs (Private Finance Initiatives).

If a government changes, or even the leader of a party changes, many of the policies change or lose focus and the construction industry will then be impacted. A recent study of Strategic Risks in the UK construction industry (Allan &

Davis, 2006), highlighted that the capriciousness of political policy and decision making was the highest risk for the industry. Even leading empirical macroeconomists like David Romer (2006) would suggest that the business cycles are largely caused by political cycles. As most OECD countries, including New Zealand, have a maximum term before general elections are held, there is an inbuilt cyclical disturbance that significantly impacts and influences any cycles in the construction industry.

### **Social/cultural/psychological cycles**

In economic terms, people are important on both supply and demand sides of an economy system. However, people are also unpredictable agents of society itself and sociologists observe patterns such as our propensity to herd, which has been credited as the cause of many stock market bubbles and crashes (BBC, 2007 and Financial Times, 2008).

There are established social and cultural factors influencing peoples' behaviour which can in turn influence purchasing and investment patterns, employment trends and even population. Different generations have different social behaviours; for example, the 'baby boomers' is a very distinct group with shared traits. Perceptions and expectations appear critical to the understanding of peoples' behaviour and their role in cyclical trends.

### **Development pattern cycles**

Construction is relatively capital-intensive. In OECD countries, 15% to 26% of the total GDP is invested as fixed capital and construction takes up half of that amount. In other words, up to 7% to 11% of GDP may be spent in construction investment. New Zealand's percentage of GDP spent on construction has historically been low compared to other OECD countries, particularly in infrastructure (Buetow, 2006). The economist Bon (2001), developed the Bon curve which suggests that developing economies start from a low percentage spend of GDP on construction, this increases during its development until it reaches a peak and then decreases steadily over time as the country develops. By implication New Zealand is a highly developed country or has been under-investing in key infrastructure for a number of years. Investment in construction by

governments, particularly in infrastructure, tends to be cyclical, according to Bon (2001) and Ruddock & Lopes (2006). This is partially due to Governments realising that they have underinvested and then playing catch up with large programmes of expenditure. This often coincides with political cycles and Keynesian policies as discussed earlier.

### Environment cycles (Forrester Cycles)

Environmental issues have become more and more crucial in making long term decisions. Global warming and climate change is already impacting both positively and negatively on individual firms in the construction industry, and the aggregate effect of this is unclear. Also, with the increased impact of natural disasters, there are new challenges and opportunities for the construction industry. In this sense, the construction industry is already experiencing the effects of environment change but the nature and duration of the fluctuation is uncertain.

### Summary of key influencing cycles and stakeholders

The key stakeholder groups have been mapped onto the different cycles to show their level of influence as shown in Figure 12. The magnitude

indicates the impact of the cycle and the time implies how long it would take to impact the construction industry.

The diagram illustrates how the nested cycles from Figure 9 affect the construction industry and other key stakeholders in different ways. Very much like stones in a pond, small pebbles dropped close by make immediate ripples on the shore, whereas large rocks dropped further away have a delay and the wave energy is dissipated depending on how far from shore it is dropped. It is not intended as a rigorous prediction tool, more a systems boundary visualisation aide. Indeed at workshops conducted during this study, this figure engendered considerable useful debate around exactly where these boundaries should be.

Whilst this analogy may be useful conceptually, it does not capture the complexity of the dynamic interaction between the various cycles and feedback loops. In practice the whole system can be interacting, causing considerable turbulence, so that one additional shock, unless very large can get lost in the confusion. Ironically, a large shock in the system can provide a degree of perceived clarity in the system. The challenge from a systems perspective is to seek the key drivers or patterns in the system.

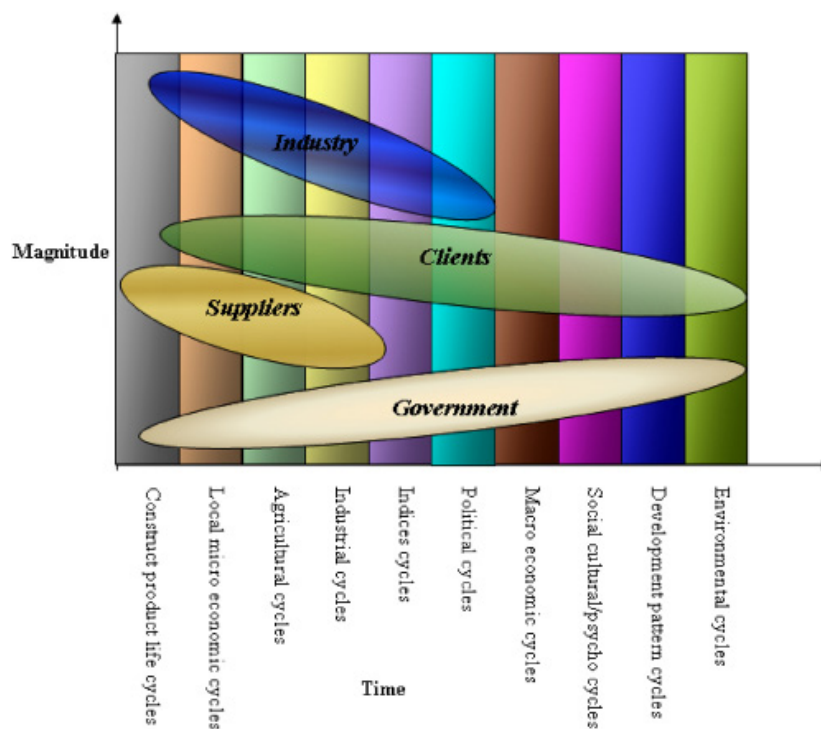


Figure 12: Different cycles related to key stakeholder groups

In Figure 13 (also see Appendix 4 for further details), a model has been developed to demonstrate how the key influencing factors of the construction industry interrelate. These interconnections have been used to help develop a theoretical systems dynamics model of key parts of industry. This approach has some benefit in testing concepts and helping industry participants to understand the system behaviour, but there are serious limitations which will be discussed in detail in later sections.

## **Conclusion of review of existing knowledge**

There is some evidence that there has been underinvestment in New Zealand construction and infrastructure over a number of years (Selwood and Buetow, 2006) yet this does not necessarily mean that it has or will induce

cyclical behaviour. Most systems, including the construction industry, tend to have self-balancing forces and behaviours which limit peaks and troughs. However, sometimes situations can cause positive, self reinforcing loops to occur which create run-away exponential growth or decline. Dot.com boom and sub-prime collapse are examples of each and are nearly always caused by behaviours driven by greed or fear. Both can be damaging to economies and industries and need to be better understood.

There does appear to be a lack of good quality information that is shared and clearly understood across the industry. Systems dynamics theories suggest that any delays in information which cause a delay in reaction to sub-optimal performance will tend to cause oscillations in output. One of the best ways to avoid cyclical behaviour is to have timely information and, where possible, have lead indicators.



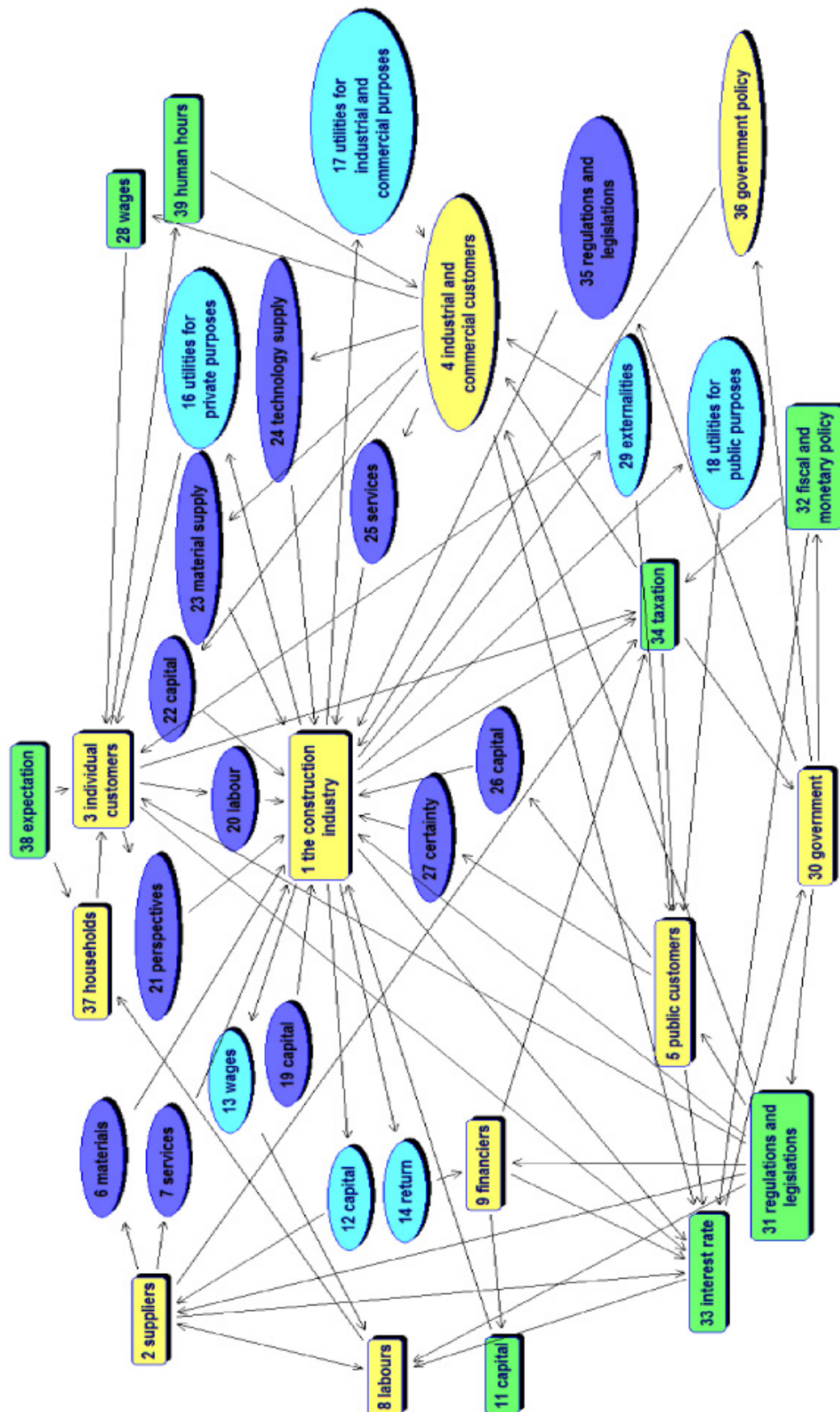


Figure 13: Interaction of key influencing factors



## PART 2: PARTICIPATIVE PHASE

Engagement was sought with key stakeholder groups to try to understand the system behaviour and key indicators that are required to better predict and understand the whole construction cyclical system. This was achieved through a series of interviews and workshops and generally followed a soft systems approach which is described in detail below.

### Methodology

This part of the study was essentially an action research project; essentially a participative process which seeks to understand through a series of interactions and testing with the stakeholders and subject matter. The key element of the action research phase of this study consisted of 14 face to face interviews with senior executives from a range of stakeholder organisations.

The conceptual development of the qualitative research process is based on *Grounded Theory*, as adapted by Blockley and Pidgeon (1991).

Grounded theory is a research method in which the theory is developed from the data, rather than the converse. It is therefore an inductive approach, and its direction moves from the specific to the more general.

Data collection and analysis are consciously combined, and initial data analysis is used to shape continuing data collection. Grounded theory thus provides detailed and systematic procedures for data collection, analysis and theorizing, but it is also concerned with the quality of emergent theory. The process of naming or labelling categories and properties is known as *coding*. Coding can be done very formally and systematically or quite informally.

The study employed a piece of qualitative analysis software called Decision Explorer, to map the connections between the codes or concepts and to analysis the presence of loops and key nodes.

In addition to Grounded Theory the other key conceptual tools used are *Personal Construct*

Interviewee's Affiliation	Description	Interviewee's Affiliation	Description
Construction Clients Group	An industry association	Roading NZ	An highway industry association
CAENZ	New Zealand Centre For Advanced Engineering	NZStrong	A leading structural designer and contractor
Opus	Consultants engaged in asset management and infrastructure design.	Fletcher Construction	A leading civil engineering contractor
Arrow International	Commercial design & build company.	Fulton Hogan	A leading contractor
ACENZ	Association of Consulting Engineers New Zealand	Canterbury University	Department of Civil Engineering
Stonewood Homes	A leading house designer and builder	Gibson Consultants	A specialist consultant
Amalgamated Workers Union (North)	The main construction industry union representative	Master Builders Federation	An industry association
Primesite Homes	A leading house designer and builder		

Table 3: Interviewees' information

*Theory* (Kelly, 1955) and *Concept Mapping*, (Eden, 1999), which is a soft systems analysis technique. Personal construct theory underpins the hypothesis that experience and perception heavily influence the decision making process of senior managers regarding key issues such as how to react to good or bad news.

Concept mapping, as advocated by McLucas (2003), was also used to analyse and understand some of the interactions and emerging issues from the case studies in the interviews.

In practice all of the techniques are used together as they complement each other and are intended to give a rich picture of the evidence and data, whilst at the same time search for new and original meaning.

## Interviews

A semi-structured interview approach was used where the researcher and interviewee worked from a predetermined set of questions. The questions acted only as a guide and were not intended to restrict the direction and depth of the interaction. The questions were sent to interviewees beforehand and are contained in Appendix 5.

## Workshops

Half day workshops were held in Auckland and Wellington to elicit feedback from key industry representatives. A presentation was made of preliminary findings to the participants and then a discussion was initiated and recorded about the problem definition, usefulness, ability to influence decision makers and future focus for the study.

The participant organisations were:

- Roothing NZ;
- Registered Master Building Federation;
- BCITO;
- Wellington City Council;
- Property Institute;
- BRANZ;
- Building Research;
- Mainzeal;
- Arrow International;

- Subcontractors Federation;
- Beca;
- Winstone Wallboards Ltd;
- Goodmans;
- HERA;
- Association Wall & Ceiling Industries Inc;
- Project Roofing; and
- Designers Institute of New Zealand.

## Soft Systems Methodology

Checkland (1999) describes a way of thinking about the complex world as *systems thinking*. Originating from what he regards as three 'problems' facing science and the scientific reductionism methodology:

1. complexity, generally;
2. the problem of extending science to include social phenomena; and
3. applying the method of science to problems in the real world, as opposed to some abstraction.

Checkland views the failure of scientific management as a consequence of the intersection of what he calls *irreducible* complexity and the real world messiness of dealing with social phenomena. Checkland is telling us that in all likelihood the study, or science, of cyclical behaviour in the construction industry is not reducible to some other well established and more fundamental science already well established. His unique perspective was to introduce the notion of *hierarchy* and *communication and control*. The complexity arises from the hierarchical composition of components, or sub-systems, and the thing that keeps the overall system in some sort of equilibrium with its wider environment is communication and control which of course leads to thinking about *feedback* based control systems and information theory. From this, Checkland then goes on to describe the General Systems Theory and the Systems Movement.

Not all of the Checkland's soft systems methodology is appropriate in this study, although taking a systems viewpoint throughout with the intention to generate conceptual and dynamic models of the systems is totally consistent with Checkland's methodology.

## Defining the system boundary

One of the first and hardest tasks is to define the boundary of the system under consideration. This was done after the interviews and clarification of the problem under consideration. What is important here is what is inside the boundary (things we must consider), outside the boundary (potential influences we need to be aware of), and what is excluded from the study (those things that are beyond our scope and control for the sake of the model). These delineations are important and the variables shown in Table 4 have arisen from the interviews and workshops.

## Outputs from one phase to the next

It became clear that there are three distinct sub-systems that interrelate in the NZ construction industry system: Private house building, infrastructure/public sector building and commercial building. There are other ways of the arranging the system but this evolved as the most natural structure:

1. **Private house building** – dominated by smaller players, customer orientated, reacts quite quickly to market forces, has little shared information and is quite volatile in comparison to the other sectors. The cycles seem to be shorter and more pronounced. Key issues are population, particularly immigration, availability of skilled workers and the level of government intervention (central and local) and regulation.
2. **Infrastructure and public sector buildings** – dominated by government spending on large one-off projects, relatively knowledgeable clients, players in this sector tend to be larger. Generally better sharing of information mainly due to government involvement. Long lead times in planning which appears to cause longer, flatter, more predictable cycles that can however become out of phase with the economic cycles. This can have an impact on funding and security of long-term contracts. Issues are continuity and availability of workforce.
3. **Commercial buildings** – which partially straddles both sectors above, is characterised by higher than average margins associated with innovation and entrepreneurship, volatility due to relatively low barriers to entry, close connection to

Inside the boundary	Outside the boundary	Excluded
GDP	Population	Internal Trade
Building sector starts	Technological change	Industrial Suppliers
Infrastructure spend	Tax rates	
Infrastructure maintenance	Oil prices	Product cycles
Inflation Rate	Exchange rates	Local economies
Interest Rate	Market cycles	Agriculture cycles
Employment	Political cycles	
Unemployment	Macro cycles	
Investment	Local cycles (Auckland)	
Housing stock	Clients	
Building sector cycles	Government procurement	
Commercial sector cycles	Environmental Issues	
Infrastructure/civil	Government regulation	
Industrial cycles	Gov. Spend decisions	
	Gov Immigration policy	

Table 4: Defining the boundaries

macro-economic trends, a mixture of clients with varying degrees of knowledge, high expectations and quick return required on investments.

The interconnectivity of the issues in each sector can be seen in the three concept maps below, which are essentially the mental construct of each sector. These were verified at the workshops with the attending industry representatives. Each key concept is represented by a node. The arrows show a connection or influence of one node on the other. It is not meant to represent a hard causal relationship. A small -ve sign shows a negative connection. As a general rule maps are organised so that arrows flow toward the top of the page.

A red node represents a key concept and is derived by a using the centrality analysis combined with the domain analysis in the Decision Explorer software. These nodes represent the most connected concepts in the system and provide a hierarchical structure to

the system. Green nodes represent the most potent concepts in the system and represent the concept that seeds the rest of the system.

In addition to the key and potent nodes the analysis looks for loops; circular connections can give clues to dynamic behaviours in the system that can be reinforcing or balancing. In systems dynamics, self-reinforcing loops can stimulate exponential growth or decline in a system, if left unchecked. This is of paramount importance in boom and bust cycles. Balancing loops provide stability and equilibrium in a system and are equally as important to understand. To explore loops in the concept map further, an intermediate step is used before attempting to build a systems dynamics model (SDM).

The process of developing a system dynamic model from the concept map is shown in the flow chart in Figure 14.

For further details see Appendix 6.



Model 1: Private House Building sector concept map





Model 2: Infrastructure & public building sector concept map



Model 3: Commercial sector concept map

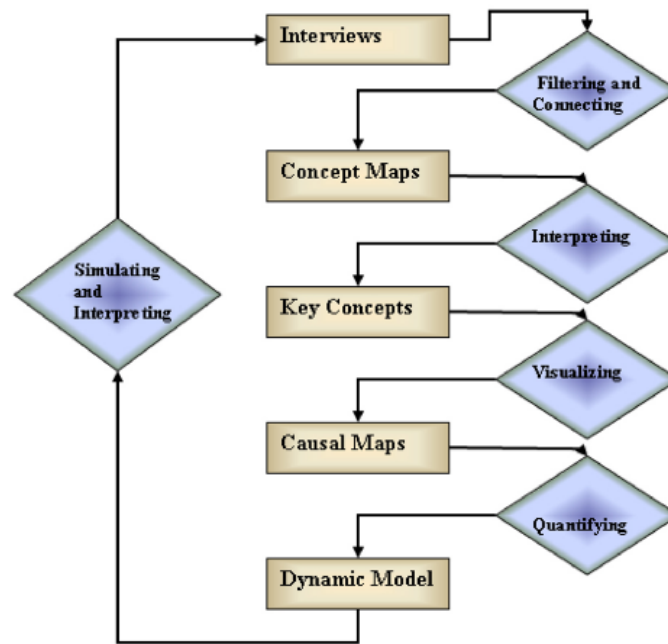
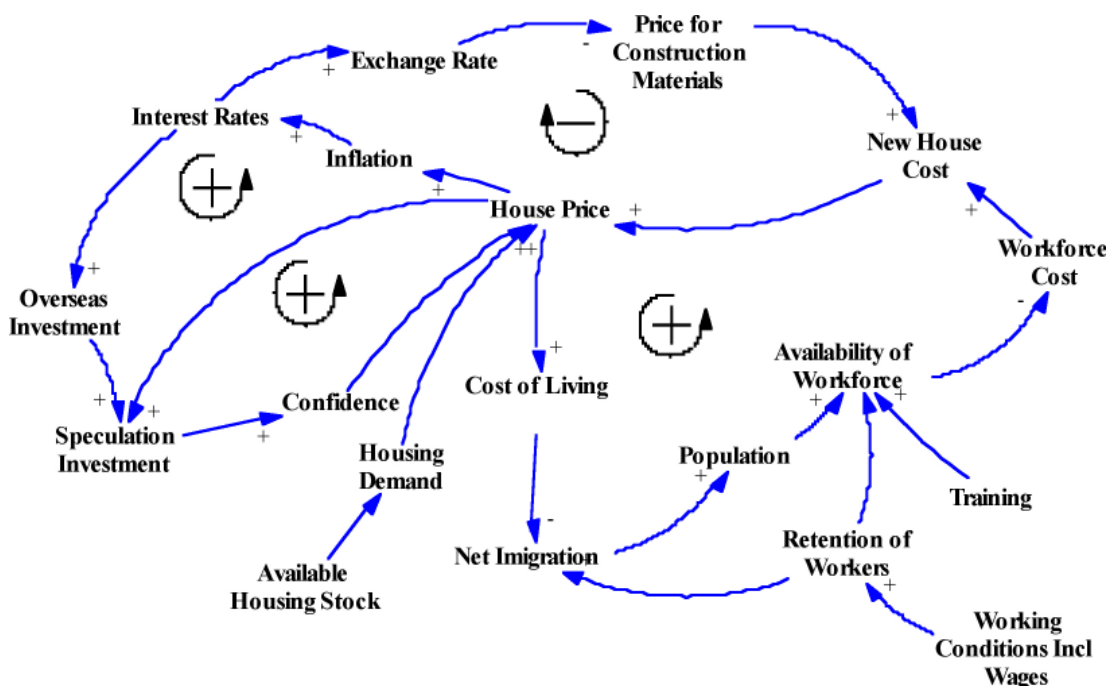


Figure 14: Flow chart of transforming maps to SDM

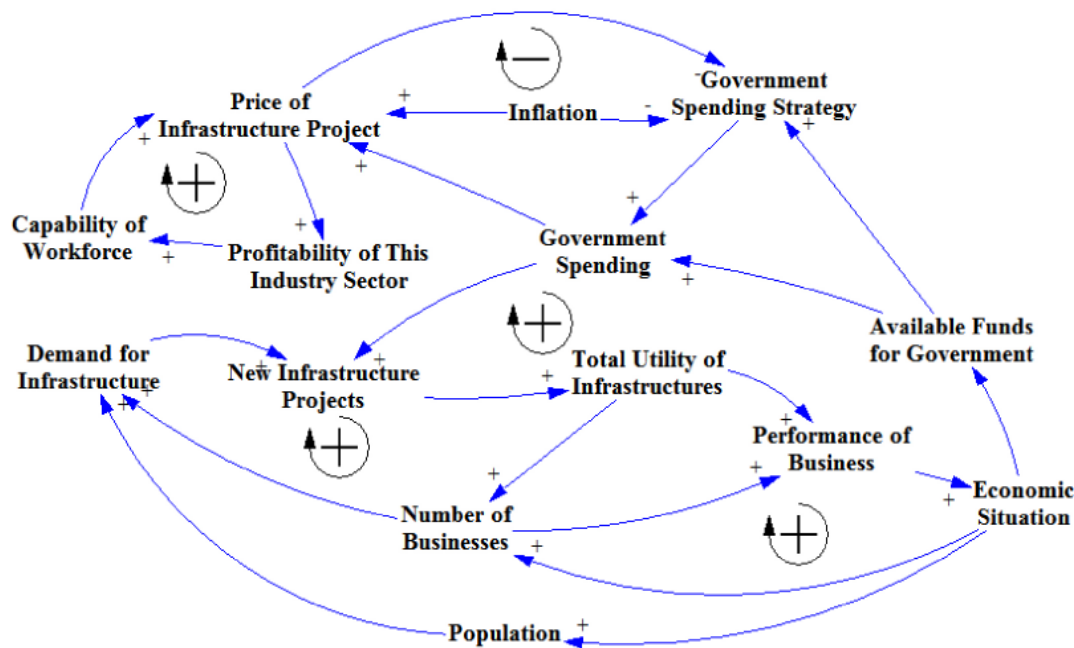
## Intermediate Causal maps

These models do attempt to look at causal links and are the start of trying to provide understanding of how the full SDM will be constructed. It is important that the logic and key loops are identified, both +ve reinforcing in

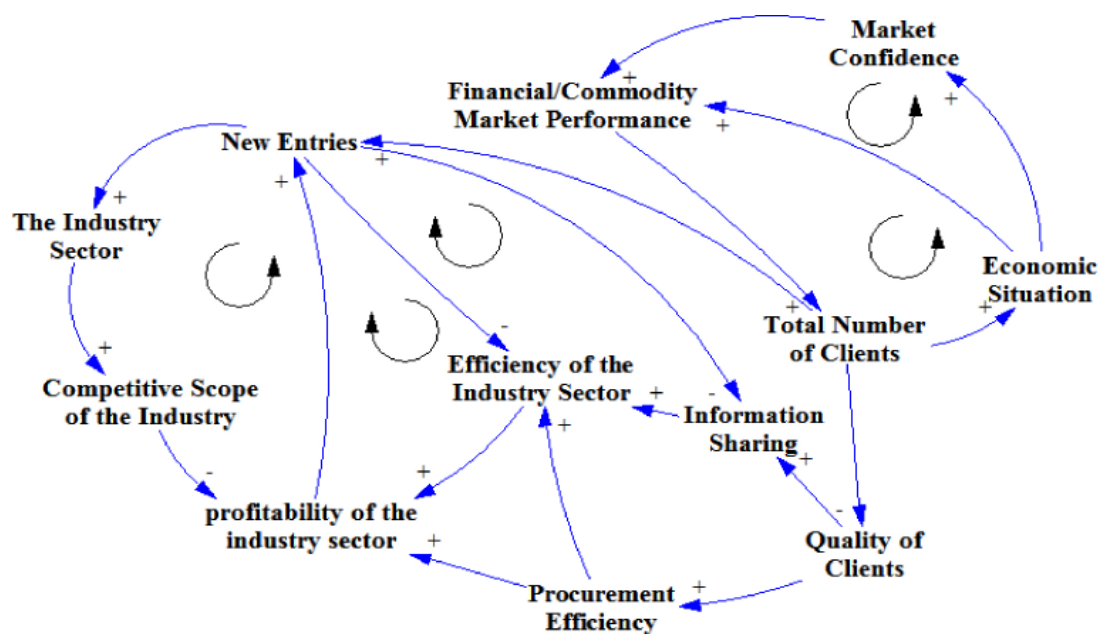
this notation and –ve balancing loops. The dynamic interactions and feedback loops are beginning to get established. However, at this stage we are not trying to establish the nature of the variable relationship, only whether one will tend to increase or decrease the other



Model 4: Private House Building sector causal map



Model 5: Infrastructure & Public Building sector causal map



Model 6: Commercial sector causal map

variables. (see Sterman (2006) for a full explanation).

## System Dynamics models

The system dynamic modelling approach used in this study is the Vensim model (Sterman, 2006). The model expresses how the system behaves and it can be animated – technically

mathematically simulated – so that its evolution, its behaviour, can be observed. This provides an immediate method of generating predictions from theory, *hypotheses*, which can be tested against the real world system in subsequent studies. One of the useful properties of a system dynamics model is that it provides an immediate test for behaviours that are at variance with general observations. It

should be stressed that the models here are only approximations and that a number of assumptions about the relationships between variables have been estimated, due to lack of correlated data. Wherever possible the relationship variables have been estimated from data or from accepted theory. Fully tested and validated models are beyond the scope of this study.

Generally they are not predictive models but aim to give insights into the system behaviour that would have been difficult to foresee. The key elements of the models are stocks represented by squares, flows represented by valves, variables and arrows indicating the direction of the flow.

## The model for the private house building sector

The system dynamic model of the private house building sector is composed of interconnected subsystems, including the industry sector, inflation, population, market demand & national account. Different systems are connected by the tangible flows, such as material and money exchanges, and intangible flows, i.e. confidence fluctuations. Detailed background theory and assumption will be illustrated in the following section.

### The Industry Sector

The construction industry's structure is represented by the flow inside the industry. The start of new projects is determined by how much money is available and the price of building new projects. When a new private housing project is initiated, it takes several months to complete the project. This can vary depending on approvals, construction and delivery time. Therefore supply delays or 'process rates' are incorporated into the model's treatment of construction time. When a house is finished, it may or may not be sold to customers directly and it is therefore necessary to build a selling process into the model.

This model also assumes that the start of new housing projects is determined by several factors (Myers 2004). Firstly, decision makers initiate new projects on business' current profitability. Secondly, market confidence level

is a determinant. If customers' confidence is low, fewer projects will move forward. Thirdly, if the unsold houses in the market exceed the market demand for new houses, the decision makers are less likely to approve new projects. These three factors together will determine the scale of new construction projects, given the available funds. If the demand for new houses is greater than the current supply, a new project will be initiated. The scale of new projects is determined by the available funds and the costs. In this process, if the market confidence is higher, more funds will be available for the industry.

### The Inflation

One of the most influential factors on unit cost is inflation. With time, the unit costs are inflated in accordance with the very basic definition of inflation (Dornbusch 2003):

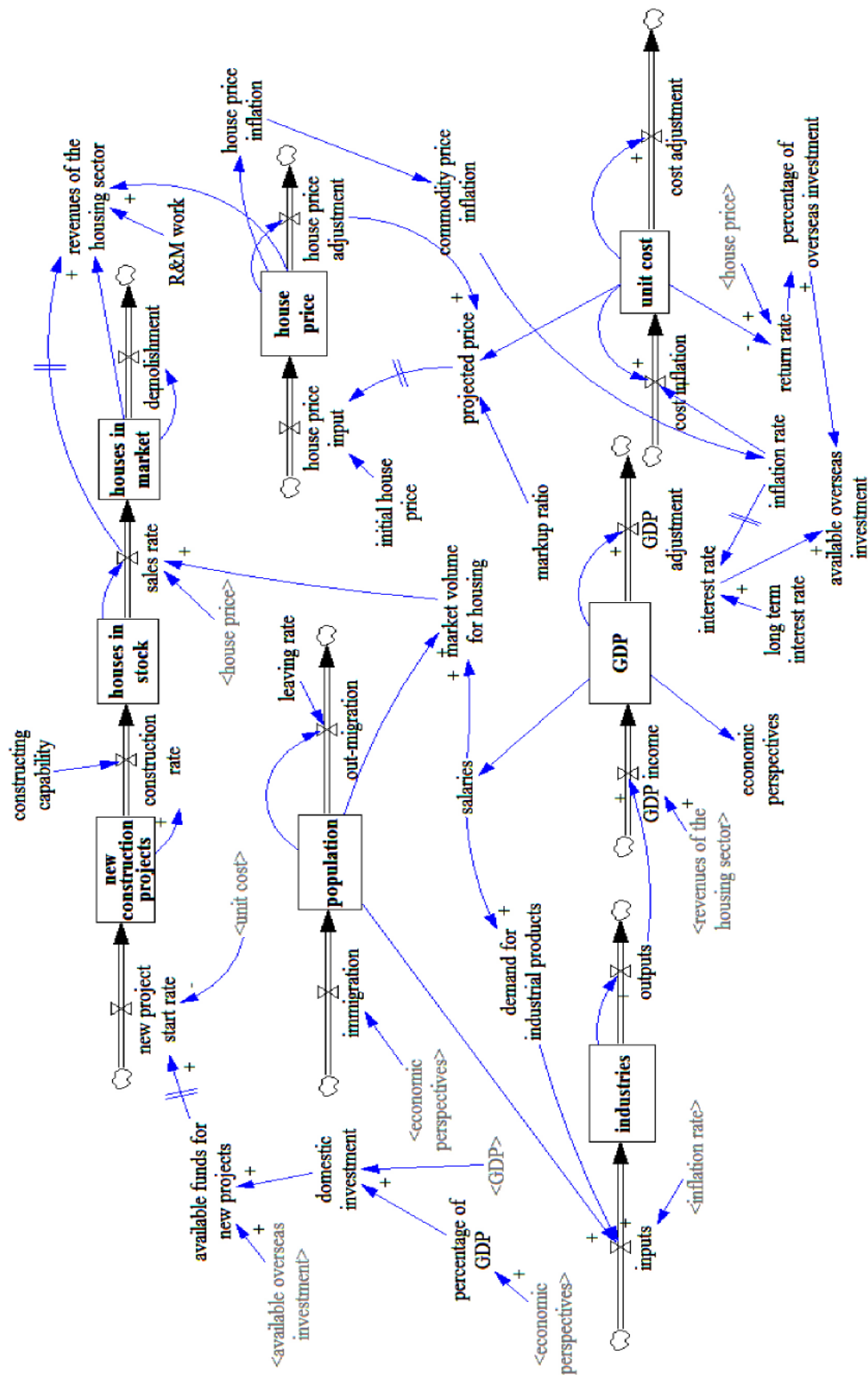
$C_{t+1} = C_t \times (1 + i)$ , where C indicates the cost, t is the time and i is the inflation rate.

Both in theory and practice, interest is closely related to inflation. Tak et al (2003) suggests that the short-term interest rate is determined by the differences between the long-term interest rate and the inflation rate. Furthermore, since the interest rate is controlled by central bankers, it would take time for them to change the policy. Therefore, a delay is modelled into the system. In this model, the long term interest rate is cited as the Secondary Market 10 Years Government Bond Yields.

### The Population

The concept of 'people' is a complicated one and because it has complex influences on the industry it has to be integrated into the model. Firstly, population directly affects the demand for construction products. Researchers, such as Greena (1996) find that the real demand for houses is proportional to the total number of people. Variables, such as house price and incomes, marital status, education, and so on, are not the determinants for housing demand, but for the purchase behaviours. In this model, this statement is modelled by creating a variable, called 'need for houses', which is approximated by New Zealand's Statistics (Statistics NZ).

Secondly, migration behaviour influences the



Model 7: Systems dynamic model of the private house building sector

country's population. Borjas (1999) suggests that economic well-being is only one of the many factors that shape migration behaviours. Environment, social and cultural factors are others that can affect people's perception of well-being. In this model, factors, such as immigration, out-migration and natural growth are expressed. According to Borjas (1995), about 80% of population arrive in the country for non-economic-driven reasons. The population, immigration and out-migration are derived from *New Zealand in Profile 2007*. Each population in this model stands for 1000 people in the real world.

### The Market Demand

Economists, such as Hillebrant (2000) state that the demand for houses is closely related to people's endogenous need. In other words, the demand for housing products is largely related to population. Literature (Shan 1999) suggests that new immigration can bring benefits to housing sector revenues.

Furthermore, some exogenous factors will affect the demand for housing products. For instance, with the development of economies and technologies, people need better living conditions and standards. Therefore, this system dynamics model assumes that the new demand for housing products is derived from two origins. Firstly, demographic factors will affect the demand for houses. Secondly, economic perspectives will affect the market demand. Indeed, economic perspective is an abstraction of all external factors other than demographic ones.

The importance of market demand to the industry is expressed as a key decision making factor. If the market demand is less than current supply, new projects are less likely to be approved. Moreover, market demand can be reflected in customers' purchase behaviours. Stephen Nickell (2004) found that house prices, financial costs of mortgages, customer income levels, and substitutive costs can all affect the purchase behaviours of housing products.

Some other microeconomic textbooks (Mankiw 2003) suggest demand-supply elasticity will affect the prices of houses. Vee (2003) reveals that price-fixing can be traced in the housing

market. So, this model integrates those concepts and provides a price model by considering house price as two parts, including the fixed and variable prices. The fixed price is assumed to be determined by the industry and the variable prices are associated with theory. The model assumes the fixed price is NZ\$1700/square metre. The variable price takes elasticity, financial costs and income into account.

### The National Account

Dornbusch (2003) and Mankiw (2003) claim the construction industry is a very important component of the national economy system. Toh (2004) quantifies that construction industry's revenue is roughly 1/25 of the total GDP of New Zealand. So, this model uses this statement and connects the industry with the whole national account. This system dynamic model assumes that individual income is fractional to the total income of the national account.

## Implications from dynamic modelling of the private housing market

### 1. *The inflation rate shapes the overall system*

*Observation:* when changing the basic inflation rate, turbulent oscillations can be observed in most parts of the model.

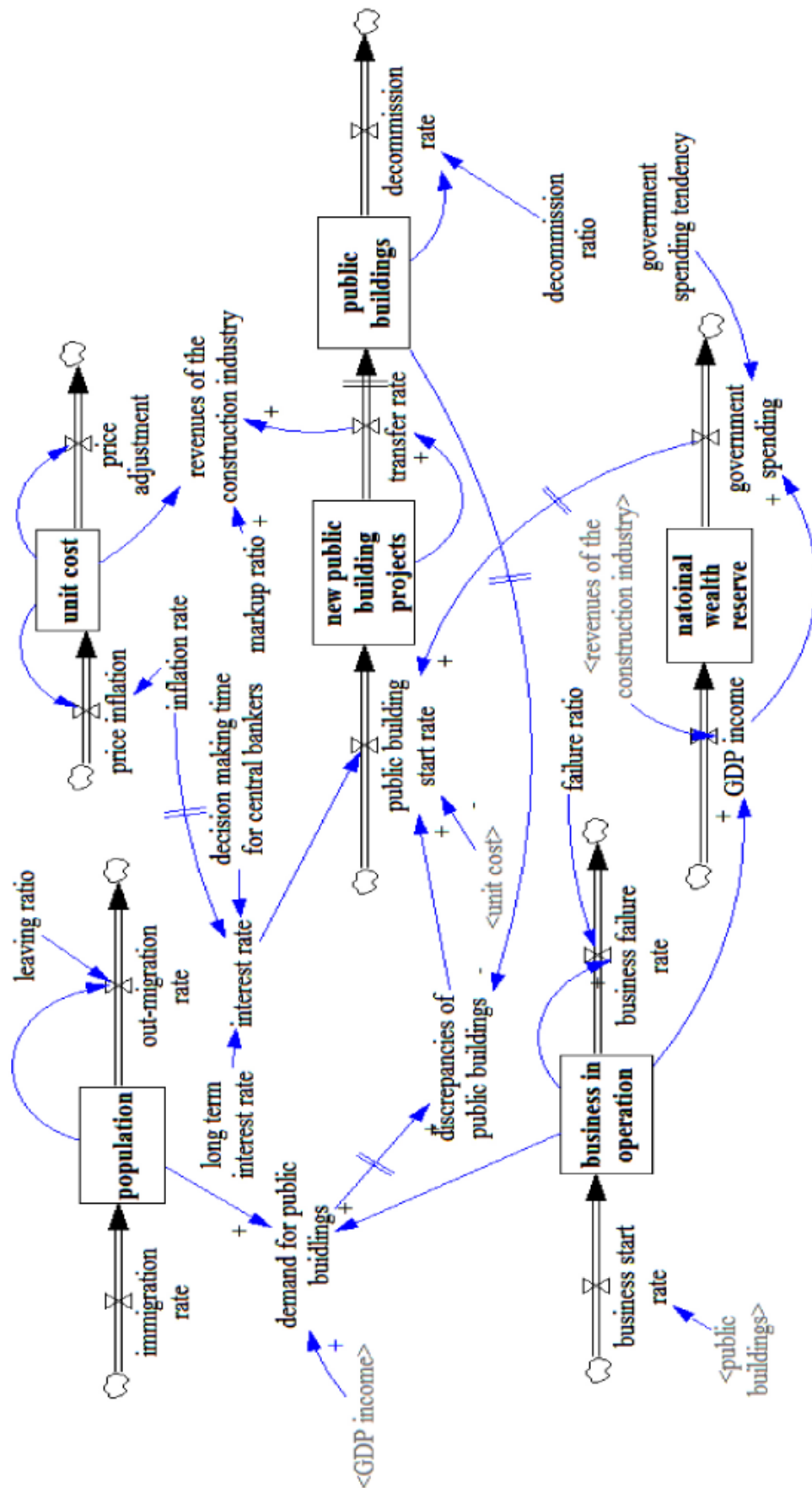
*Possible explanations:* in this version, inflation is not an exogenous variable as the inflation rate can be traced back to house prices. When the house price increases significantly, the inflation goes up as well. The pattern of inflation follows an exponential trajectory, suggesting a positive reinforcing loop.

### 2. *Setting the house price high does not necessarily guarantee a steady growth*

*Observation:* initial house price is a key variable to control the housing system. Increasing the initial house price and the perturbation in the overall system is significant. At a certain price tipping point, the system goes into an exponential decline, even before the end of the simulation process.

*Possible explanations:* in a certain range, a higher house price can lead to higher builder revenue. But, if the price goes





Model 8: System Dynamic model for infrastructure & public buildings

beyond the rational range and the house price increases too fast, people are less likely to afford to buy houses. Instead, they may resort to substitutes, such as renting and renovating. On the other hand, the revenue of the industry can be enhanced by increasing the sales rate. Given the pricing trend in recent decades, a steady sales rate can guarantee growth of the industry. Therefore, it is necessary for the industry sector to seek a price to stabilise sales volume, rather than speculate on short term price increases.

### **3. The housing market cannot grow indefinitely**

*Observation:* the curve of the housing sector's revenue has a trend to regress beyond a certain range, no matter how the other variables are manipulated.

*Possible Explanations:* this model integrates many negative feedback loops and several decision making points. This would suggest the model is based on more rational balancing assumptions and behaviours. However, in boom phases, people tend to make over-optimistic decisions and projections of the future, maybe driven by greed. The herding effect is powerful in these conditions and people are prone to making irrational investments, causing instability in the overall system.

### **4. Being too responsive to market change may not be helpful in managing fluctuations**

*Evidence:* if the decision to set prices is shortened, the fluctuations become very significant.

*Possible explanations:* as known, fluctuations in system dynamics (SD) models are usually caused by the differences between steps that are induced by delays. If a decision maker is over responsive to price change (shorten the decision delay), they will change their pricing strategy promptly in accordance with market. This would make the market situation even more turbulent in the short term, though this might reverse the trend in the longer term.

However, changing the price once the market has changed cannot help the industry reduce the impact of fluctuations. Additionally, the prompt response to price changing could further affect the market's confidence level and thus amplify the effects of cycles.

## **The system dynamic model for infrastructure and public buildings sector**

This model simulates the public building sector from four aspects, including the construction industry, the government, other industries and the people in New Zealand.

### **The Industry Sector**

One of the most significant differences between the infrastructure & public building sector and the private housing sector is the involvement of the customers. Literatures and practitioners agree that government bodies are more knowledgeable and proficient than normal householders and play more much significant roles (Rowlinson, 1999). This is a reason why households are referred to as customers and government bodies are often called clients. Their viewpoints have to be taken into account in the designing process. Not only involved in the designing processes, government also performs the role of procurer of the final products. If the government is not satisfied with the construction products, it may consider alternative strategies in initiating new projects.

In this model, the mark-up ratio is assumed to be 30% and it can change by a factor between 0 and 1.

### **The National Account**

In most circumstances, better infrastructure can improve the efficiencies of the economy (Boarnet 1999). So, this model assigns a coefficient to indicate its supportive role in the economy. In return, these businesses can contribute to the wealth of the country.

### **Population**

This section of the model uses the same logic as that in the private housing sector. It is assumed that New Zealand's population is affected by the economic conditions of the country. The demand for infrastructure and public buildings is proportional to the total population.

### **Other Industries (Businesses)**

The end users of public infrastructure and buildings can be roughly categorized into two

groups, including individual people and other industries. This model assumes that other industries use the public utilities to operate. So, a ratio can be assigned to the public building to represent its capability of supporting businesses. If current capabilities cannot meet current demand or future demand, government will consider more projects to meet the gap.

## Implications from modelling the infrastructure and public buildings sector

### 1. *An increase in expected government spending has a great impact on both construction industry and the macro economy.*

*Observation:* While other variables remain unchanged, government spending can exert significant influence on the system. In this SD model, government spending is composed of the spending tendency, the available funds and the delay in decision making. If the Government adjusts its spending tendency by increasing the percentage of GDP committed to new infrastructure constructions, the construction industry revenues become more cyclical and the overall economy experiences a boost. However, as the spending tendency increases so the revenue cycles and the economy as a whole becomes more volatile with significant downward swings.

*Possible explanations:* The observation is similar to the effects suggested by Keynesian economic principles, though there appears to be an upper limit which also concurs with Keynesian critics. Since the start of new public projects is largely determined by government policy, the expectation of investment is also crucial to the overall system. When more money is injected back to the system, more buildings will be available to businesses; more jobs are created which increases GDP. However, if Government investment is excessive, with the country possibly incurring a high national deficit, this provides significant instabilities into the system which in turn causes the fluctuations.

### 2. *The delay in public projects is a cause of fluctuations.*

*Observation:* given other variables remain

unchanged, if the decision delays (in whatever form) are increased, greater fluctuations will appear in the revenues of the construction industry. Conversely, quicker decision making smooths the fluctuations.

*Possible explanations:* if decision makers are more sensitive to market change, they can identify any gaps between need and supply, and hence react promptly to bridge the gap. This would make the market more certain and therefore reduce the level of turbulence. This observation is totally consistent with Sterman's (2000) bull-whip affect.

### 3. *Retaining people in NZ is crucial.*

*Observation:* when the leaving ratio of people increases, the revenue of the construction industry drops and fluctuations appear across the system. Or, more likely, as the population increases the industry may become more stable with increased revenues.

*Possible explanations:* the start of public projects is determined by the discrepancies between demand and supply. Population is a key determinant of the demand. Clearly if people kept leaving the country, ongoing project utility is negated; resources are scarce, costs rise which all lead to a set of self-reinforcing destruction loops for the industry. This also lends support for the controversial view that an increased population would benefit construction and the country's economy overall.

### 4. *Controlling costs of public buildings is a good way to smooth cycles.*

*Observation:* when initial unit costs for public projects are raised, the disturbances in the system tend to be more turbulent.

*Possible explanations:* although higher price can lead to higher revenue, higher cost produces more rapid downward trend as more projects get cancelled, delayed or revised to meet a shrinking budget.

### 5. *A policy of not selecting the lowest tender price for public construction projects, particularly in the downward part of the cycle, can help the industry smooth the fluctuations and increase the revenues in a long run.*

*Observation:* when mark-up is increased, significant turbulences during the starting

period of the revenue curve are smoothed. In a longer term, the overall revenue of the industry increases. Moreover, the GDP income and national wealth reserve increases accordingly.

*Possible explanations:* a higher mark-up ratio for public projects can make the industry more attractive and hence more resilient to counter fluctuations.

#### **6. Inflation rate shapes the boom/bust symptoms.**

*Observation:* when inflation rate stays low, i.e. in the current range between 1.8%-3% per yr, the fluctuations appear in the beginning part of the revenue curve. When the inflation rate increases, the whole revenue curve oscillates. If the inflation rate reaches a very high level, say 20% per yr, the revenue curve shows very chaotic fluctuation behaviour.

*Possible explanations:* inflation rate is an accumulative factor exerting influences on the whole economy. High inflation rate is transmitted from one sector to another and then fed back into the next loop. Since inflation is included in many positive loops, it is not surprising to see rapid exponential growth and decay. This would make for a very challenging business environment, with almost random business and industry failures.

## **The model for the commercial building sector**

The system dynamic model for the commercial building sector is primarily composed of three subsystems, including the industry sector, the financial environment (costs and inflation), and the macro economy system (population and the national account). The aim of this industry sector is to meet the demand from other industries by providing construction products and services.

### **The Industry Sector**

The commercial buildings' lifecycle is modelled as the backbone of the industry sector. When new projects are initiated, they will be put on the project schedule. Since the capability of the industry is not infinite, new projects have to queue to start and then finish. Moreover, the delivery of the commercial buildings from

construction companies to the client takes time to complete. In real world scenarios, many interested parties will be involved in this process, such as government bodies, agencies, designers who exert influences on the project. All of these issues are simplified as the variable, called delivery rate.

Since the model skips market agents, the clients are assumed to interact with the industry directly. This is represented in the pricing of commercial buildings. In this model the raw profit margin is set as 30% but can change in a broad range.

The decision model for new commercial construction projects is assumed to be the same as the private building sector. If the current commercial buildings cannot meet the demand, decision makers will initiate new projects. The scale of new projects is adjusted by market confidence.

### **Inflation and Costs**

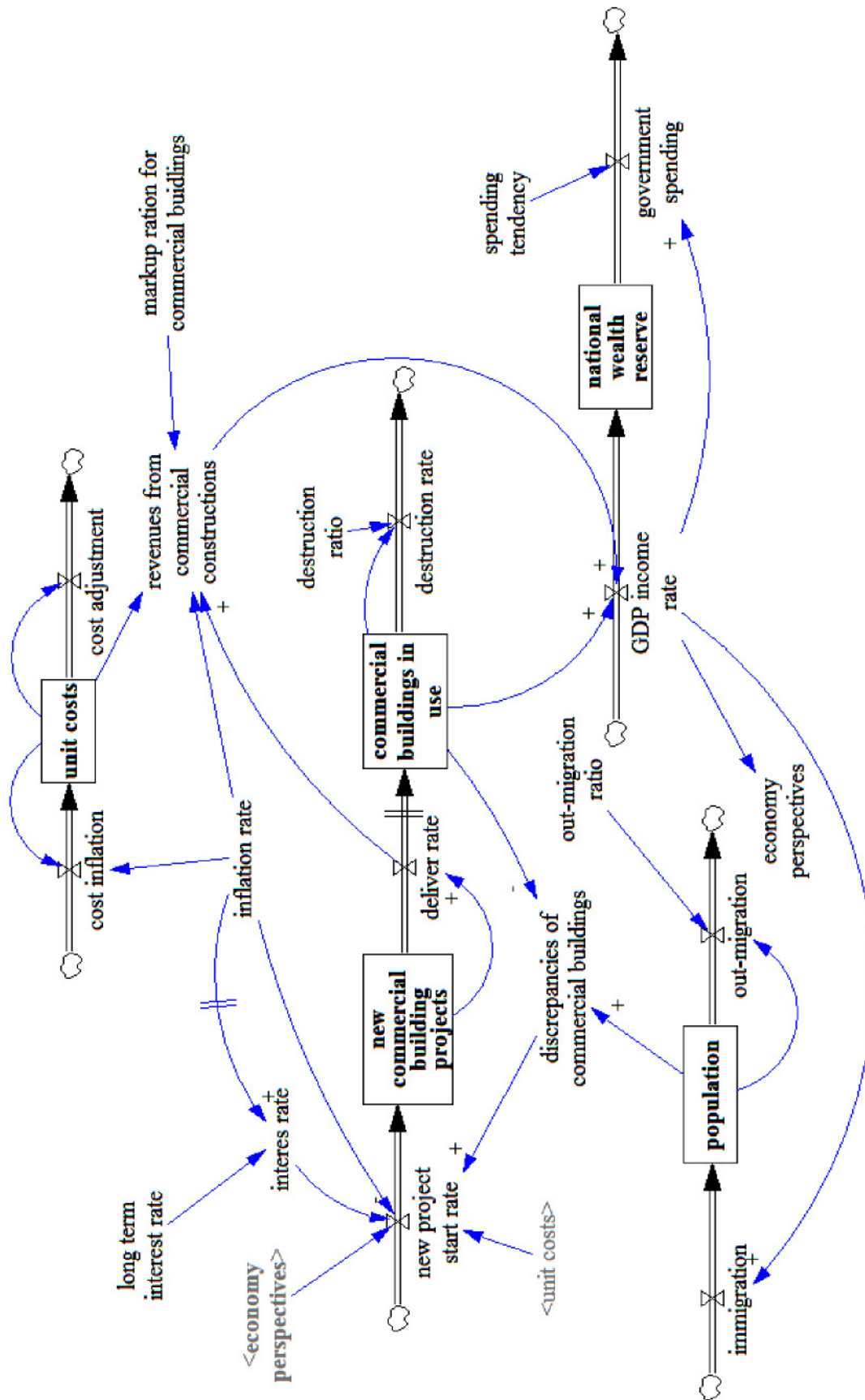
The mechanisms of inflation and costs are identical to those in the private building sector. Inflation rates can affect on-going projects by changing the costs. Also, the inflation rate can affect the industry by influencing the interest rate and hence adjusting new approvals of projects. Material costs and labour costs are determined by initial costs and inflation.

### **The National Account**

Nana (2003) quantifies the economic correlations between the construction industry and other industry sectors. This system dynamic model adopts some of the concepts in that report by simplifying all other industry sectors as one variable and connects it with the construction industry through the National Account. The economic activities related to the commercial buildings can be simplified as a coefficient to reflect the productivity, which can be further transmitted to the National Account as GDP income. Furthermore, GDP can affect the confidence level of the investors.

### **Population**

This section also uses the same theories of migration as those in the model for the private building sector. The demand for commercial buildings is assumed to be associated with the



Model 9: System Dynamic model for the commercial building sector



population of the country. A variable, called the need per capita, is set to reflect the relationship between the demand and the total population.

### **Implications from the modelling of the commercial sector**

#### **1. Delivery rate is crucial for managing boom/bust cycles**

*Observation:* delivery rate is measured by the delivery time. A shorter time indicates a higher delivery rate. When the delivery time is short, fluctuations will be quite concentrated at the beginning part of the revenue curve. This might be merely an inherent overshoot of the system model itself, which has no connection to reality. When the delivery time is prolonged, significant fluctuations appear and the duration of fluctuations increases as well.

*Possible explanations:* A quicker delivery of construction projects will reduce uncertainty and make the duration of shocks shorter.

#### **2. Cost is a key factor influencing the boom/bust cycle**

*Observation:* when other variables are fixed, the increase of initial costs of the unit costs for commercial buildings will amplify the fluctuations, in terms of scale and duration.

*Possible explanations:* Since the model is largely based on loops with inflation being highly connected in the model, it means every month the cost increases, ultimately limiting the growth of the sector.

#### **3. The influence of interest rates is not as significant as expected**

*Observation:* when the interest rate is varied, the revenue curve of the construction industry barely moves. (*This could however be due to a modelling anomaly*)

*Possible explanations:* In conventional economic theory, interest rates are presumed to be an important decision factor. However, in this model's decision making process, the interest rate does not exert great influence. This may reflect that in the real world, people do not always base their decision making on rational facts. Investors may pursue projects, providing the business case is sound and do not always take full regard of the 'Net Present Value' of investments. Also it may indicate foreign

investment where local interest rates are not so relevant.

#### **4. Keeping attracting more people to NZ may smooth the fluctuations**

*Observation:* when the variables related to population are changed, for example, increasing the constant level of immigration, the building demand curve is smoothed. This is similar to the effect in the private housing market model.

*Possible explanations:* In the model, when more people are retained in the country, the fluctuation patterns are not too turbulent. In other words, the country is experiencing 'population benefits'. Therefore, it is necessary to control the fluctuations by attracting more people to the country.

#### **5. The overall commercial building demand will reach an equilibrium point**

*Observation:* the simulation shows no matter how the variables change, a final steady state of the commercial building sector should be reached. This is unusual in such a SD model.

*Possible explanation:* Though it fluctuates, an equilibrium level can be identified by this model. It appears demand & supply economics does pervade this sector. However, participants at the workshops indicated that the sector is really quite volatile so there must be some destabilising influence at play, but not yet understood.

#### **6. People's perspective is important**

*Observation:* people's perspective on the future of the economy is largely determined by the time delay function. This can change the revenues of the construction industry quite dramatically.

*Possible explanations:* When people use past experience to predict current or future economic conditions, they will be affected by bias in the time frame of the data they use. Recent matches are more likely than longer term historical data and experience. Commonly people forget periods of recession and high interest rates in favour of more recent evidence. These biases could be a cause of these fluctuations. Therefore, it is necessary to make people more aware of the data limitations and their predictions.



The challenge then is to combine these system maps (or SDM's) and findings into a set of key drivers that represents the complexity of the interrelatedness of the different cycles within the whole system. The usefulness will be partially dependant on the availability of good data to input

into the model, which itself appears to be a common issue for the industry, but also how understandable it is. As mentioned before in this report, most people have great difficulty in integrating more than two or three dynamic variables.



## PART 3: SUMMARY & RECOMMENDATIONS

The economic system is probably one of the most complex systems ever developed by man. Boom-bust cycles are the emergent phenomenon from that complex adaptive system and are generally undesired as they create in economic terms what is known as 'waste' in the system. It is unlikely therefore, that there can be a reliable predictive tool for the construction industry in New Zealand to manage these cycles. However, this report proposes that a systems approach is a helpful way to model and understand the root behaviours and patterns that emerge from complex systems such as the New Zealand construction industry.

In respect of this system, the study has utilized a systems dynamic modelling approach to better express how the construction sector behaves under a boom/bust cycle. The observations from the analysis undertaken are set out below:

### The model for the private house building sector

1. The inflation rate is a central node and shapes the overall system.

When changing the basic inflation rate, turbulent oscillations can be observed in most parts of the sector.

2. Setting the house price high does not necessarily guarantee a steady growth.

Initial house price is a key variable to control the housing system. Increasing the initial house price results in the fluctuations in the overall system becoming more significant. At a certain tipping point price, the system goes into an exponential decline.

3. The housing market cannot grow indefinitely.

The curve of the housing sector's revenue has a trend to regress beyond a certain range, no matter how the other variables are manipulated.

4. Being too responsive to market change may not be helpful in managing perturbations.

If the decision delay in adjusting prices is shortened, the fluctuations become very significant.

### The model for infrastructure and public buildings sector

1. An increase in expected government spending has a great impact on both the construction industry and macro economy.

Given that other variables remain unchanged, the spending tendency variable, which is an expectation variable, for government spending changes from current levels to a higher level, the GDP and construction industry's revenue rise accordingly. When the spending tendency is much higher, significant disturbances and fluctuations occur. At very high rates the trend is for the economy to go into decline.

2. The delay in public projects is a cause of fluctuations.

Given other variables remain unchanged, if the decision delays (in whatever form) are increased, greater fluctuations will appear in the revenues of construction industry. Conversely, quicker decision-making smooths the fluctuations.

3. Retaining people in New Zealand is crucial.

When the leaving ratio of people increases, construction industry revenue drops and fluctuations appear across the system. Or, more likely, as the population increases the industry may become more stable with increased revenues.

4. Controlling the costs of public buildings is a good way to smooth cycles.

When initial unit costs for public projects are raised, the disturbances in the system tend to be more turbulent.

5. A policy of not selecting the lowest tender price for public construction projects, particularly in the downward part of the cycle, can help the industry smooth the fluctuations and increase the revenues in the long run.

When the mark-up is raised, significant turbulences during the starting period of the revenue curve are smoothed. In a

longer term, the overall revenue of the industry increases. Moreover, the GDP income and national wealth reserve increases accordingly.

6. Inflation rate shapes the boom/bust cycles.

When the inflation rate stays low, i.e. in the range, which we have seen historically, of between 1.8%-3% per year, the fluctuations appear in the initial part of the revenue curve. When the inflation rate increases, the whole revenue curve oscillates. If the inflation rate reaches a very high level, say 20% per year, the revenue curve shows very chaotic fluctuation behaviour.

### The model for the commercial building sector

1. Delivery rate is crucial for managing boom/bust cycles.

Delivery rate is measured by the delivery time. A shorter time indicates a higher deliver rate. When the delivery time is short, fluctuations will be quite concentrated at the initial part of the revenue curve. When the delivery time is longer, significant fluctuations appear and the frequency of fluctuations increases as well.

2. Cost is a key factor influencing the boom/bust cycle.

When other variables are fixed, the increase of initial unit costs for commercial buildings amplifies any fluctuations, in terms of scale and duration.

3. The influence of interest rate is not as significant as expected.

When the interest rate is varied, the revenue curve of the construction industry barely moves. One cannot of course rule out a modelling anomaly here but one of the most useful aspects of system dynamic modelling is that it often throws up counter intuitive results.

4. Continuing to attract more people to New Zealand may smooth the fluctuations.

When the variables related to population are changed, for example, increasing the constant level of immigration, the building demand curve is smoothed. This is similar to the effect in the infrastructure and public building model.

5. The overall commercial building demand will reach an equilibrium point.

The simulation shows no matter how the variables change, a homeostasis state of the commercial building sector is reached. This is an unusual condition in this sort of system dynamic model (see comment in 3 above)

6. People's perspective is important.

People's perspective on the future of the economy is largely determined by the time delay function. This can change the revenues of the construction industry quite dramatically.

In conclusion, these emergent properties of the system that characterise the industry lead to the following points:

- Government related policies and decisions such as infrastructure spending, interest rates and immigration have a systemic impact on the construction industry.
  - The size and profitability of the construction industry has a significant long-term impact on the overall economy.
  - Much of the construction industry boom/bust effects are caused by the industry's own internal system structure rather than external shocks.
- The industry in its totality is characterised by complex and often ill-defined supply chain relationships. These are wider and more dynamic than most in the industry recognise or understand.
- This uncertainty, often fuelled by misconceptions and shocks to the supply chain, can lead to a 'bullwhip effect', leading to undesired outcomes.
- There are multiple levels of interdependencies of stakeholders in the industry, including government.
- The so-called 'reinforcing loops' dominate all sectors of the industry but are more prevalent in the domestic housing sector.
- These loops can cause highly non-linear behaviour, rendering history a poor predictor of future cycles.
- Things will need to be done differently if the industry wishes to ensure its long-term profitability and sustainability.

### Key Recommendations

The construction sector is an important contributor to the New Zealand economy and

the health of the industry is a bellwether of the overall state of the New Zealand economy.

The key motivation for action should be based on the above finding that much of the construction industry boom bust effect in New Zealand is actually caused by the industry's own internal system structure and behaviour rather than external shocks. This means that the way forward requires the industry and policy makers to adopt new thinking that:

- Recognises how co-dependencies and industry dynamics drive behaviours and profitability.
- Utilises systems thinking to understand the perceptions and related behavioural aspects that create damaging self-reinforcing loops and bull whip effects.
- Establishes sector level indicators of conditions that encourage boom bust type cycles rather than using broad economic data.
- Adopts structures and cultures that reinforce communication and information sharing throughout the industry, particularly across industry sectors.
- Encourages long-term strategic thinking instead of short-term profit seeking and speculation.

In essence, the way forward requires that the industry embrace shared learning and greater collaboration. The systemic behaviours behind the drivers of boom/bust cycles are well engrained in the culture of society and will be slow as well as difficult to change. However, in the short-term the construction industry could smooth the peaks and troughs of the cycles to a large extent by adopting some or all of the recommendations below:

1. Government and large organisations should minimise delays in their procurement process and make the forward planning for, and the actual progress of, construction projects transparent to the rest of the supply chain.
2. Delays in initiating Government approved and funded projects should be reduced. Procuring faster, smaller projects rather than rolling together projects together would help the industry as a whole, despite the impacts to individual stakeholders.
3. Setting up a construction industry alliance to share information across the entire supply chain and to champion the change in thinking described above.
  - a. A similar approach to that of, the then, TransitNZ could be adopted, which appeared to work well in providing efficiencies and continuity of work in the highway sector.
  - b. It is recognised however, that there are a plethora of industry associations, professional bodies and interest groups. A new group or body could easily get lost amongst the other initiatives. The new alliance must not look after individual member interests but rather be charged with looking after the health of the industry as a whole.
  - c. Whilst Government should be a key stakeholder in such an alliance it must be owned by the whole industry and directed by a small yet representative group. Industry and government bodies at the highest level should act upon recommendations from the alliance.
  - d. At a practical level, Government should provide significant funding for the alliance set up and functioning with matched funding from industry contributions.
  - e. Government and industry sectors will need to supply good quality, regular information about workloads, prices, delays etc. Some funding may be necessary to initially set up these information and monitoring systems.
4. The simple fixed price competitive tender model (which the probity rules of some government agencies demand) does not fit with maintaining a holistic view of the industry and should be replaced with a value added contractual approach. Fixed price competitive tenders are only really appropriate for higher volume contracting where there are standard designs and many competitors, for example the housing market and basic roading works.
5. Retaining and training skilled and semi-skilled workers is critical to controlling the worst effect of the fluctuations. Employment conditions need to become more attractive and internationally competitive.
6. Government should refrain from using construction as a blunt economic tool to

control inflation and unemployment without fully understanding the systemic implications and dynamic affects it may induce.

7. The industry should adopt and apply good cost estimating and cost control, with particular attention given to inflationary rises and methods for accounting for this.
8. The commercial building sector appears to quickly reach a tipping point due to over investment, which produces very turbulent conditions across the industry as a result. Some form of self-regulation needs to be exercised in this sector to avoid inexperienced, speculative investors over stimulating the whole industry. The result is a rapid loss of capital from the industry which then takes years to return.
9. Simple systems simulation software should be developed as an education toolkit and freely distributed to training departments, professional bodies and universities. (There are numerous software products available that could be bought cheaply and adapted to a New Zealand context).
10. Inflation is clearly a key factor in shaping the underlying construction system but more research into this relationship, and how the sector might better recognise emerging trends, is required. Also, more research on what impacts people's decisions about the economy which then shapes their behaviours, despite contradictory evidence, is also required.



# REFERENCES

- Allan, N. and Davis, J. (2006), Strategic Risks – thinking it differently. Proceedings of the Institution of Civil Engineering, *Civil Engineering Risk Special*, Vol 159, London
- Allweyer, T., B.-E., T., S. Leinenbach, and A.-W. Scheer (1996). Model-based reengineering in the European construction industry. *itc.fgg.uni-lj.si*.
- Australian and New Zealand Standard Industrial Classification* (1993), N. Z. S. Australian & New Zealand Bureau of Statistics.
- Beinhocker, E. D. (2006), *The Origin of Wealth: Evolution, Complexity, and the Radical Remaking of Economics*. Boston, Massachusetts: Harvard Business School Press.
- Blockley, D., Turner B. & Pidgeon, N. (1991), The Use of Grounded Theory for Conceptual Analysis in Knowledge Elicitation, *International Journal of Man-Machine Studies*. 35(2): 151-173
- Boarnet, M. G. (1999). Road Infrastructure, Economic Productivity, and the Need for Highway Finance Reform, *Public Works Management & Policy* 3(4): 289-303.
- Bollard, A. E. & Hunt, C. (2008). *Coping with shocks – a New Zealand perspective, address to the Canterbury Employers' Chamber of Commerce*, January 2008.
- Bollard, A.E. (1992) *The Impact of Economic Changes on the Construction Sector*, The New Zealand Institute of Economic Research (NZIER), Wellington
- Bon, R. (1990) The World Building Market 1970-1985, *Building Economics and Construction Management: Proceedings of the CIB W65 Symposium*, Sydney.
- Borjas, G. J. (1995). The Economic Benefits from Immigration, *The Journal of Economic Perspectives* 9(2): 3-22.
- Borjas, G. J. (1999). *The Economic Analysis of Immigration: Handbook of Labor Economics*. Cambridge, MA.: Harvard University Press.
- Bourn, S. J. (2001). *Modernising Construction*. London, National Audit Office, UK.
- Cebula, R. J. and R.K. Vedder, (1973). A note on migration, economic opportunity, and the quality of life, *Journal of Regional Science* 13(8).
- Checkland, P.B., 1999. *Systems Thinking, Systems Practice: Includes a 30 year retrospective*. Chichester: Wiley.
- CIPD, (2007), *Annual survey report 2007*, Chartered Institute of Personnel Directors, UK
- Cox, J., Ingersoll, J.E. and S.A. Ross (1985). A theory of the term structure of interest rates, *Econometrica* 53(2): 385-407.
- Deloitte, (2006), *2005-2015 Construction Demand/Capacity Study*, Full Report. O. o. G. Commerce.
- Donaldson, P. (1992). *Economics of the Real World*, London: Penguin Group.
- Dornbusch, R. (2003). *Macroeconomics*, New York: McGraw-Hill Higher Education.
- Eden, C. (1994), Cognitive Mapping and Problem Structuring for Systems Dynamics Model Building, *Systems Dynamics Review*.
- Financial Times (2008) <http://www.ft.com/cms/s/0/ceafc5d8-41ea-11dd-a5e8-0000779fd2ac,s01=1.html>
- Greena, R. and P.H. Hendershott, (1996), Age, housing demand, and real house prices, *Regional Sciences and Urban Economics* 26(5): 465-480.
- Grimmond, D. (1989). Investment, Growth and Public Policy, Working Paper 89/27, *Institute of Economic Research*, New Zealand

- Grimmond, D. (1989/89-20): An Analysis of the Sectoral Effects of Disinflation on Output, Employment and Investment, Working Paper 89/20, *Institute of Economic Research*, New Zealand
- Haugen, R. A. (2001). *Modern investment theory*. Upper Saddle River, NJ: Prentice Hall
- Hillebrant, P. (2000). *Economic Theory and the Construction Industry*, third edition, London: Palgrave.
- Hunn, N. (1989). *Financial Deregulation and Disinflation in a Small Open Economy: The New Zealand Experience*, Research Monograph 44, Institute of Economic Research, New Zealand
- Kelly, G.A. (1955), *The Psychology of Personal Constructs*, New York: Norton.
- Lee, L. H., Padmanabhan, V. and S. Whang, (1997), the Bullwhip Effect in Supply Chains, *Sloan Management Review*, Spring 1997.
- Mankiw, G. N. (2003), *Macroeconomics*. New York: Worth.
- Mansfield, E. (1988), *Principles of Macroeconomics*, sixth edition, New York: W.W. Norton & Company.
- McLucas, A.C. (2003) *Decision Making: Risk Management, Systems Thinking and Situation Awareness*, Canberra, Australia: Argos Press
- Myers, D. (2004). *Construction Economics – a new approach*, New York: Spon Press.
- Nana, G. (2003), *Assessment of the Economic Impact of Efficiency Improvements in Building and Construction*, Business and Economic Research Limited.
- Nickell, S. (2004), *Household Debt, House Prices and Consumption Growth*, Bloomberg in London.
- OECD, April (2007). *Economic surveys: New Zealand*, Organisation for Economic Co-operation and Development
- Page, I. (2005). *Levy long term drivers and forecasts*, project no QC5020, BRANZ Ltd., Research report E399
- Porter, M. E. (1985). *Competitive advantage: creating and sustaining superior performance* New York: The Free Press.
- Romer, D. (2006), *Advanced Macroeconomics*, New York: McGraw-Hill.
- Rowlinson, S. M. and P. McDermott, (1999). *Procurement Systems: A Guide to Best Practice in Construction*, New York: Taylor & Francis.
- Ruddock, L. and J. Lopes, (2006) The construction sector and economic development: The 'Bon' curve, *Construction Management and Economics*, 24.
- Selwood, S. and P. Buetow, (2006). *Infrastructure Development in Comparative Nations: Insights for New Zealand*, NZCID.
- Shan, J. (1999). Immigration and Unemployment: new evidence from Australia and New Zealand, *International Review of Applied Economics* 13(2): 253-260.
- Sterman, J. D. (2000). *Business Dynamics: Systems Thinking and modelling for a Complex World*. Boston: Irwin McGraw-Hill.
- Tak, Y., Wong, J. Hui, C. and Seabrooke, W. (2003). The impact of interest rates upon housing prices: an empirical study of Hong Kong's market, *Property Management* 21: 153-170.
- Toh, C. (2004). *An analysis of the contribution of the New Zealand's construction sector to the national economy*, Centre for Advanced Engineering, University of Canterbury.
- Vee, C. and R.R. Skitmore, (2003), Professional ethics in the construction industry, *Engineering Construction and Architectural Management* 10(2): 117-127.
- Zavadskas, E. K. and K., Arturas (2005), working out a rational model of Lithuanian construction industry development, *Journal of Business Economics and Management* 6(2): 71-80.

## Web Pages

BRANZ: [www.branz.co.nz](http://www.branz.co.nz)

British Broadcast Corporation inside  
Business: [www.bbc.co.uk/business](http://www.bbc.co.uk/business)

Competitive Building:  
[www.competitivebuilding.org](http://www.competitivebuilding.org)

Constructing Excellence:  
[www.constructingexcellence](http://www.constructingexcellence)

Construction Industry Council (CIC):  
[www.nzcic.co.nz](http://www.nzcic.co.nz)

Construction Innovation Forum:  
[www.cif.org/index.htm](http://www.cif.org/index.htm)

Cooperative Research Centre for Construc-  
tion Innovation:  
[www.construction-innovation.info](http://www.construction-innovation.info)

Ingenium: [www.ingenium.org.nz](http://www.ingenium.org.nz)

Lean Construction Institute:  
[www.leanconstruction.org](http://www.leanconstruction.org)

LEEDS (Linked employer- employee data)  
Statistics NZ  
[http://www.stats.govt.nz/store/2008/05/  
linked-employee-employer-data-  
mar07qtr-hotp.htm](http://www.stats.govt.nz/store/2008/05/linked-employee-employer-data-mar07qtr-hotp.htm)

National Technology Agency of Finland  
(TEKES): [www.tekes.fi/eng](http://www.tekes.fi/eng)

Process and System Innovation in the  
Construction Industry (PSIB):  
[www.psib.nl](http://www.psib.nl)

Provisional Construction Industry Co-  
ordination Board (PCICB):  
[www.pcicb.gov.hk](http://www.pcicb.gov.hk)

Statistics New Zealand  
[www.stats.govt.nz](http://www.stats.govt.nz)



# APPENDICES

## Appendix 1: Segmentation of construction industry

### Divisions

E41 General Construction

E42 Construction Trade Services

### Groups:

E411 Building Construction

E412 Non-Building Construction

E421 Site Preparation Services

E422 Building Structure Services

E423 Installation Trade Services

E424 Building Completion Services

E425 Other Construction Services

### Classes:

E4111 House Construction

E4112 Residential Building Construction nec

E4113 Non-Residential Building Construction

E4121 Road and Bridge Construction

E4122 Non-Building Construction nec

E4210 Site Preparation Services

E4221 Concreting Services

E4222 Bricklaying Services

E4223 Roofing Services

E4224 Structural Steel Erection Services

E4231 Plumbing Services

E4232 Electrical Services

E4233 Air Conditioning and Heating Services

E4234 Fire and Security System Services

E4241 Plastering and Ceiling Services

E4242 Carpentry Services

E4243 Tiling and Carpeting Services

E4244 Painting and Decorating Services

E4245 Glazing Services

E4251 Landscaping Services

E4259 Construction Services nec

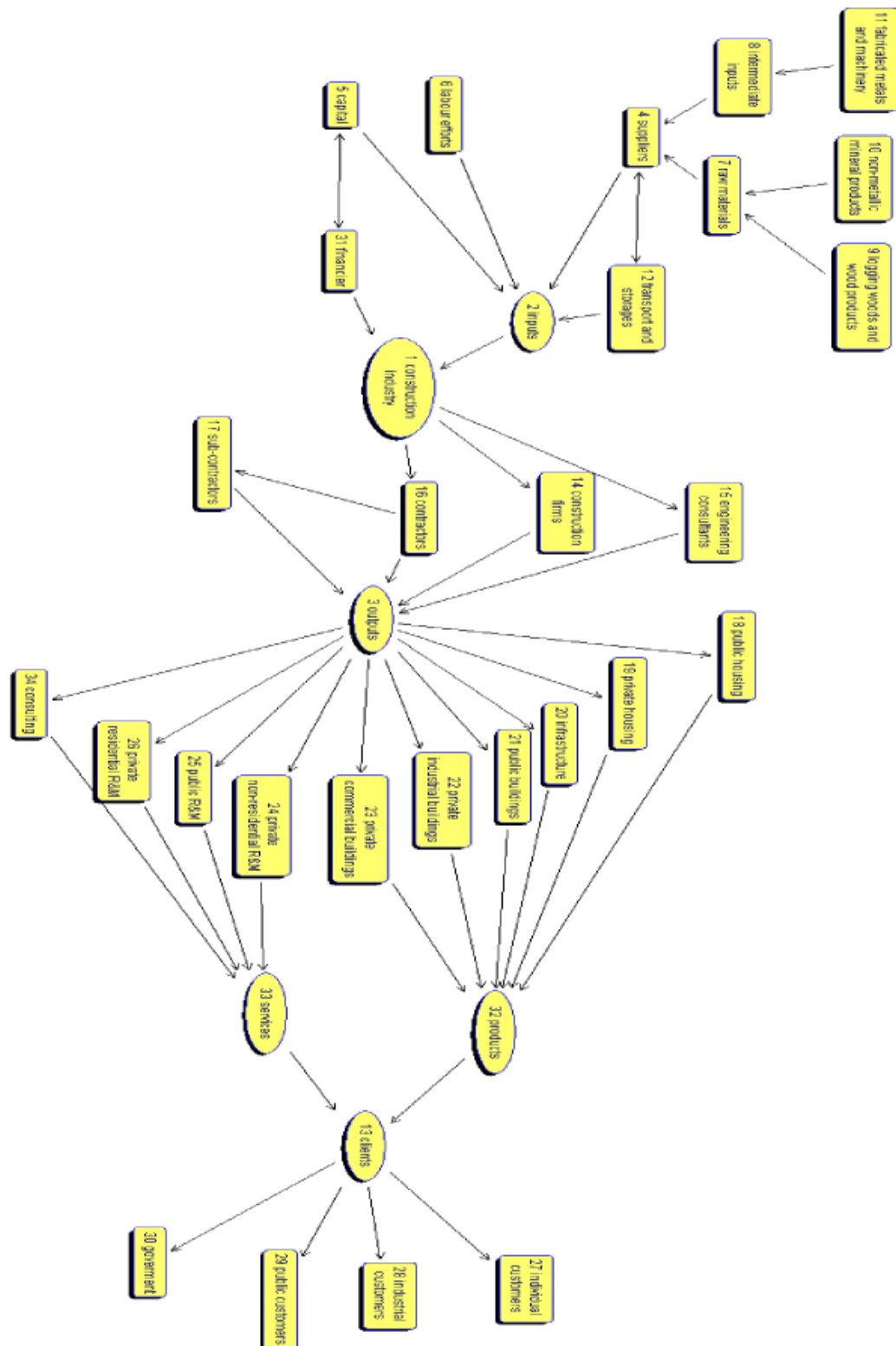
### Deloitte's Approach:

- Public Housing
- Private Housing
- Infrastructure - Water, sewerage, electricity, gas, communications, air transport, rail, harbours and waterways, roads.
- Public Non-residential building - Schools and colleges, universities, health, offices, entertainment, garages, shops, agriculture, miscellaneous, factories, warehouses, oil, steel, coal.
- Private Industrial - Factories, warehouses, oil, steel, coal.
- Private Commercial - Education, health, offices, entertainment, garages, shops, agriculture, miscellaneous.
- Housing R&M - also includes improvement works, extensions and conversions
- Public Non-residential R&M - Includes repair and maintenance on both public non-residential buildings and public infrastructure
- Private Non-residential R&M - Includes repair and maintenance on private industrial and commercial buildings and private infrastructure

## Appendix 2: A System Model of the Construction Industry

A system model of construction industry is derived from the following resources: 1, government documents ((1993), and (Bourn 2001)); 2, government statistics (Statistics New Zealand); 3, commercial reports ((Nana 2003),

(Buetow 2006), (Toh 2004)); 4, classical textbooks ((Mankiw 2003), (Myers 2004), (Hillebrant 2000)); journal articles ((Allweyer.T 1996), (Zavadskas 2005) and etc); and other resources (BBC Business, Ft.com).





## Appendix 3: Different Theories of Business Cycles from different Economic Schools

### 1. Classical Keynesian Theories

#### *Traditional Keynesian theories of fluctuations:*

there are barriers to the instantaneous adjustment of nominal prices and wages. Sluggish nominal adjustment causes changes in the aggregate demand for goods at a given level of practices to affect the amount that firms produce. As a result it causes purely monetary disturbances to change employment and output. In addition, many real shocks, including changes in government purchases, investment demand, and technology, affect aggregate demand at a given price level. The Keynesian model begins with specific static relationships between variables. Traditionally, Keynes' model is summarized by two curves in output-price or output-inflation space, an aggregate demand (AD) curve and an aggregate supply (AS) curve. This model is often derived from IS-LM model. the LM curve shows the combinations of output and the interest rate that lead to equilibrium in the money market for a given price level. Currency and reserves are taken into consideration. The IS curve shows the output-interest rate combinations such that planned and actual expenditures on output are equal. The IS-LM model suggests many potential sources of fluctuations: **changes in monetary and fiscal policy, shocks to investment demand, shifts in money demand function, real exchange rate, planned expenditure, wages, price rigidity, labour market**, and so on.

### 2. The New Keynesian Theories

Theorists of new Keynesian economics think economy fluctuations represent deviations from the economy's natural rate. They think these deviations occur because wages and prices are slow to adjust to changing economic conditions. One reason prices do not adjust immediately in the short run is that there are costs to price adjustment. Some menu cost may happen. A deeper rooted reason is that a price reduction by one firm benefits other firms in the economy. When a firm lowers the price it charges, it slightly lowers the average price level and thereby raises real money balances. The increase in real money balances expands aggregate income. The economic expansion in

turn raises the demand for the products of all firms. This macroeconomic impact of one firm's price adjustment on the demand for all other firms' products is called an aggregate-demand externality. This school of advocates suggest that the recessions result from a failure of coordination. In recessions, output is low, workers are unemployed, and factories sit idle. If the society fails to reach an outcome that is feasible and that everyone prefers, then the members of society have failed to coordinate in some ways. Coordination problems can arise in the setting of wages and prices because those who set them must anticipate the actions of other wage and price sectors. In general, those economists believe that the monetary and fiscal policy should be used to try to stabilize the economy. Price stickiness is a type of market imperfection, and it leaves open the possibility that government policies can raise economic well-being for society as a whole.

### 3. Austrian Theories

Business upturns and downturns have **predictable features**, such as the fact that luxuries benefit more from upturns and suffer more from downturns than necessities. Similarly, durable goods & technological goods benefit disproportionately from upturns and suffer disproportionately in downturns. For this reason durable goods production is a more sensitive indicator of recession than retail sales — and this is most especially true for producer durables (machinery & equipment) rather than consumer durables (automobiles, furniture, etc.). Unemployment is regarded as a lagging indicator of recession because businesses will try to cut costs in many ways (reduced advertising, reduced capital spending) before resorting to laying-off workers who have training & experience. Economists who blame recession on excess inventories confuse cause & effect.

**Austrian Business cycle model:** fractional reserve banking only became possible through the outlawing of private money and the creation of central (ie, government-controlled) banks — which allowed governments to

control money supply and bank credit expansion. In a free market interest rates are determined by subjective time-preference and the supply & demand of loanable money. If there is a low rate of savings the quantity (supply) of loanable money will be low and competition for this money (demand) by potential borrowers will result in high interest rates. High interest rates will encourage more savings and thereby bring the price of loans (interest rates) downward. As with supply & demand for any good or service, a free market will find a “clearing price” for the supply & demand of loanable funds. This clearing price is the **natural rate of interest**. Central bank control of money & short-term interest-rates in national economies is at the root of contemporary business cycles. When central banks artificially lower short-term interest rates below natural market levels, this results in two major distortions in capital markets. First, those who would save money receive less than the natural rate of interest — and this disincentive to save actually reduces the amount of loanable funds in real (as distinct from nominal) terms. Second, those who would borrow money for large capital projects are paying less than the natural rate of interest — thus encouraging borrowing investors to believe that capital projects are more sustainable than they really are. Artificial lowering of interest rates by central banks is thus accompanied by expansion of the money supply — resulting in an artificial stimulus to spending for both consumer goods and capital goods. This artificial stimulus results in **an inflationary boom** which is not sustainable. Central banks are ultimately forced to raise short-term interest rates to counteract the inflation, resulting **in a bust**. Supporters of central bank monetary manipulation justify the practice as a means of levelling-out the business cycle when, in fact, central banker monetary manipulation is the cause of the business cycle.

#### 4. The Neo-classical Theories

The **Exogenous growth model**, also known as the **Neo-classical model** or **Solow growth model** is a term used to sum up the contributions of various authors to a model of long-run economic growth within the framework of neoclassical economics. Policy measures like tax cuts or investment subsidies can affect the

steady state level of output but not the long-run growth rate. Growth is affected only in the short-run as the economy converges to the new steady state output level. The rate of growth as the economy converges to the steady state is determined by the rate of capital accumulation. Capital accumulation is in turn determined by the savings rate (the proportion of output used to create more capital rather than being consumed) and the rate of capital depreciation.

#### 5. The Real Business Cycle Theories

**The Real business cycle theory:** the economy consists of a large number of identical, price-making firms and a large number of identical, price-taking households. The inputs to production are capital, labour and technology. Output is consumption, investment, and government purchases. The government's purchases are financed by lump-sum taxes. The capital-market is perfect. People would like to make a trade-off between working hours and leisure. Also, the consumption and investment tradeoff is important to people. The basic model predicts that given a temporary shock, in terms of innovations, bad weather, imported oil price increase, stricter environmental and safety regulations, etc, output, consumption, investment and labor all rise above their long-term trends and hence formulate into a positive deviation. Furthermore, since more investment means more capital is available for the future, a short-lived shock may have an impact in the future. That is, above-trend behavior may persist for some time even after the shock disappears. This capital accumulation is often referred to as an internal “propagation mechanism” since it converts shocks without persistence into highly persistent shocks to output. It is easy to see that a string of such productivity shocks will likely result in a boom. Similarly, recessions follow a string of bad shocks to the economy. If there were no shocks, the economy would just continue following the growth trend with no business cycles. In the short term, the **interest rate** would not affect the employment rate significantly while affecting the consumptions and investment. **Government purchase** would affect the economy with +1 multiplier. **Taxation** is deemed as a kind of interest and it would affect market output quite similarly to interest.

## Appendix 4: Influencing Factor Model

Four key groups of elements are defined as the supply side (suppliers, labours and financiers), the construction industry, clients (households, individual customers, industrial and commercial customers, and public customers), and the government. The construction industry is influenced by several tiers of factors, either as inputs or outputs. Many logical loops, which may have multiplying effects and periodic properties, can be perceived to be influencing the industry.

The first tier factors influence the construction industry directly. The most noticeable ones include:

- **Materials**

As the basic input of the construction industry, the material *flows* connect the industry with suppliers. Prices, quality and timeliness are major concerns of the two sides of the supply chain. Inadequacies or redundancies in supply will exert negative influences on the industry. Serious inflation or deflation will be detrimental to the whole economy. Classic economic theories would blame business cycles for the failure of market coordination of the material supply.

- **Services**

Both the construction industry and the suppliers provide services to other parties of the economic system. There are many forms of services, both tangible (R&M, designing, insurance and etc) and intangible (expert knowledge, advisory and etc). Services could be the input of the industry as well as the output. Moreover, services are the connection between the industry and clients. Procurement, as a complex service, is a hot topic nowadays. Any change in the demand or supply side of the services will affect the industry.

- **Capital**

Another basic input of the construction industry is the capital flow. As pointed out before, the construction industry is capital-intensive. New projects need heavy investment to initiate and under-construction projects require ongoing capital to move forward. Another attribute is the relatively long return periods, which often exceed the tolerance of general companies.

Consequently, many special financial instruments are devised to finance the construction industry. Therefore, periodical fluctuations in the capital market have great influences on the construction industry.

- **Technologies**

Many commercial and government reports identified that technology has a direct influence on the construction industry. Technology not only improves the industry, but also affects the demand and supply of the industry. To a large extent, every technology breakthrough in human history affects the construction industry fundamentally. Most of these changes are heavily related to the infrastructure sector of the industry, for instance, railway construction, highway network construction, city infrastructure improvement projects, or even recent internet and mobile facilities etc. Periodic technological breakthroughs inject stimulus into the construction industry and hence contribute to the cyclic patterns.

- **Perspectives**

Expectations and confidence are two basic indicators of an individual's perspectives, and it is these perspectives which determine peoples' behaviours. As most people are not rational all of the time, understanding perspectives becomes a key to understanding behaviour. Market signals are translated into business actions via the feedback loop of a person's perspective. Periodic patterns of peoples' behaviour, or the 'flocking behaviour', will at times affect all industries including the construction industry.

- **Labour**

As the essential player in the economic system, labour not only contributes human hours to an industry but also consumes the products. They are also a major resource of capital. Any fluctuations in labour market, in terms of employment, salary rate, skills, and productivity, will affect the business cycle of the construction industry.

- **Certainty**

Several reports, commissioned by the New Zealand government, suggested the lack of certainty is a driving force of fluctuations. Uncertainty about the future can lead to inefficient allocation of resources, which is

reckoned to be the driving force of fluctuations.

- **Regulation and legislation**

As demonstrated in the influence model, government is a key element in the system, exerting influences over every other element. Periodic political change is recognized as a potential cause of the business cycle.

- **Tax and interest policies**

Tax and interest are the major monetary and fiscal policies to regulate market behaviour. Regulators are inclined to adopt aggressive measures to control the economy.

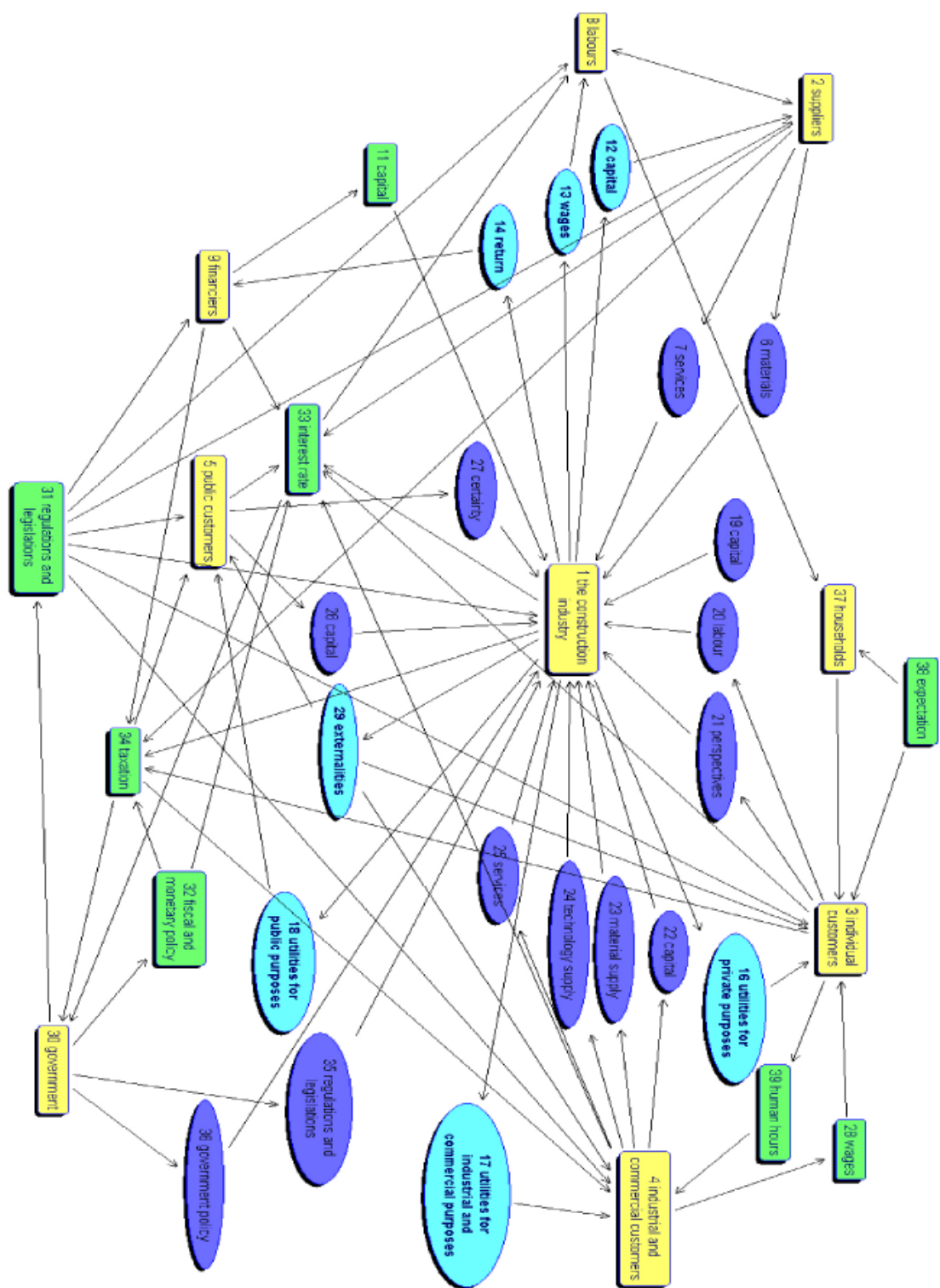
- **Utilities of construction products**

In economic terms, products are units of utility and hence they are of value. The utility of a construction product may be valuable at the beginning of its lifecycle. However, due to the long lifetime expectation and the turbulent changes in custom-

er's requirement, the utility may depreciate faster than it is designed to, such as certain infrastructures. Or the utility may remain stable, such as housing products. The irregular fluctuations of the utilities of a construction product can occur on a large scale. The result may affect industry and thus cause a significant turbulence e.g. UK rail infrastructure

- **Externalities**

Some construction economists consider the externalities of the construction industry, such as external utility, wastes, etc, to be vital factors in decision making. If the costs of externalities are far less than the benefit, the construction industry seems to have a better opportunity to boom. For instance, people are more willing to invest in new construction if the external costs are negligible. The proper control of the externalities can be an effective means to control the cyclic patterns.



## Appendix 5: Interview Questions

Need to establish what is the interviewees background, qualifications, experience and current position etc.

Qu1 - How did you arrive at your current position?

Need to know what sectors and role the organisation they represent plays in the construction industry.

Qu2 – In what capacity does your organisation influence or impact the construction industry?

Qu3 – What other key stakeholders in the industry do you regularly interact with to achieve your objectives?

Qu4 – How much influence do you as an individual and your organisation have on the growth of the industry?

Need to understand why and how they see boom bust cycles occurring.

Qu5 – Do you think there are boom/bust cycles in the New Zealand construction industry and what are their nature, eg how long and deep?

*If not then go to Qu 9*

Qu 6 - What do you see are the major causes of these cycles, please elaborate as much as possible as this is important for us.

Qu 7- Please can you give us some examples from your experience of boom and/or bust situations. How they begin and develop and what measures did you take to cope?

Qu 8 – Who do you think are the key people who should control recessions and booms. How could they be the most effective?

Qu9 – How well would your organisation cope with continuing growth in the industry, how would you manage this?

Qu10 - What are the foreseeable threats to the construction industry? How might these manifest themselves.

Qu11 - How well would your organisation cope with a severe downturn in the industry over the next 6 months? What actions would you take?

Qu12 - Is there anything else you would like to add that you think is important and we should have asked you?

Many thanks for your time and insights!



## Appendix 6: Transforming Concept Maps to Dynamic Models

### 1. The private house building sector

The concept map of the private house building sector is based on data derived from the interviews with industry practitioners. In a concept map, the number of connections attached to a concept reflects connectivity and hence importance. In this concept map, the variables, New House Demand (7) and Housing Demand Decline (12) are the most connected. One attribute of them is that both are associated with 'demand'. Analyzing concepts that are closely coupled with 'Demand', such as Rise in Price (8), Positive Immigration (6), and Supply Chain (5) provides an insight into the mechanism for housing demand. Also, some of the concepts are indirectly connected to 'Demand' and integrating them can enrich the picture. Those concepts include Market Uncertainty (25), Marketing Process (4), Delay in Consent (13) and Emigration from NZ.

Another cluster of concepts that deserves attention surrounds the finance environment. Interviewees raised many issues about the finance aspects of the industry sector, including (3), (18), (19), (22), (23), (24), (25) and (29), all of which can be roughly categorized into 3 subgroups. Firstly, the Inflation (23) is significant and is directly related to Unemployment (24) and Economic Downturn (18), reflecting the conventional definition of 'economy cycle'. Secondly, the availability of consumer finance affects the demand of houses Variable (19), (20), (22), and (25) are directly linked with the cost of money. Thirdly, overseas investment is linked to New Zealand's housing market. Variable (2), (22) and (29) are the major concerns of overseas investors. Also linked here is the construct that if there are enough incentives, such as high interest rate and confidence in the economy, there is a tendency to throw Dumb Money (3) into the domestic market.

A third cluster of concepts, represents the macro economic situation and includes concepts about the finance environment. Variables (14), (6) and (27) show the influence of government policy making. Resource Management (28) affects the supply side of the construction industry whilst the Supply Chain

(5) is an expression of the overall system.

Variables (16), (17), and (21) emphasise the human aspect, especially the labour aspects of the system. , Variables (10) and (20) are the so-called 'exogenous factors or shocks to the economy'. Variables (9) and (13) highlight the dynamic behaviour of the industry. From interviewees' perspective, the concept 'delay' is central to the industry system.

By studying the overall system model represented above there appears to be three subsystems: house demand, the financial environment and the macro economy. Some concepts are floating and act to connect different parts of the system, Finally soft concepts, such as market confidence and speculation, are integrated into the simulation process as auxiliary variables. .

### 2. The Infrastructure and Public Building Sector

Compared with the Private Building Sector, the Infrastructure and Public Building Sector is heavily dependent on the government. Adopting the same approach as in the previous section, four major groups of concepts can be established albeit with more sparse connections.

Government is a noticeable attribute of several variables, including (1), (9), (10), (14), (15), (16), and (19). Variable (19) reflects the government's current risk appetite, which is evolved from Variable (21) and (20), and hence influences spending strategies (16). Government's policy, through tax and tariff (2) will affect the system significantly. The public (9), on the other hand, can exert pressures on the government and force it to modify their strategies (14).

Another group of key concepts relates to human resource issues including recruitment (6) retention (28), layoffs (7) and apprenticeships (27). Also, interviewees emphasize the working processes of the industry sector such as reducing the lead time of construction project (17), shortening cycles (18), sharing information (24) and smooth work flows (26). Linked together these provide an interesting construct. Interestingly, better reputation (22)

is linked to making the industry more attractive which may to some extent mitigate some of the HR , workforce problems (28),

In this industrial sector's concept map, variables related to finance environment can exist as an independent group. Among those variables, pricing strategy (13) and (29) can influence the profitability of the sector. Inflation (11) and Tax (2) can influence government's spending policy via several feedback loops with amplified loops...

Furthermore, concepts that are related to macro economy system of New Zealand formulate another cluster. If real world events signal hinders to the economy (4), interviewees would expect to see forthcoming downturn in the future (3) and thus adjust themselves to the new circumstances, i.e. sack workforces (7). Interviewees' strategies would like to adapt accordingly, for example, asking higher prices for new projects (13) to build up the resilience of the company (23). Also, people can expect government undertake plans, such as launching large infrastructure projects (14) and cut taxes (2), to boost the economy. In the long run, this loop may reduce government's treasury position (15), leading to a concentrated budget for infrastructure projects (14). Other industries are also screwed into the system by exchanging workforces (12) and collaborating in terms of sharing information (24) and joint action (25).

In these regards, a systems dynamic model can be built on three subsystems, in terms of government's behaviours, the macro economy, and the industrial sector together with the financial environment. Particularly, the concept of time ((17) and (18)) and implicit variables, such as speculations on economy (4), can exert significant influences on the simulation process.

### 3. The Commercial Sector

Compared with previous concept maps, the commercial sector distinguishes itself by engaging in extensive market activities. Here, the term 'market' implies the whole economic system which is composed by the construction industry and other industries. If a boundary of the construction industry is drawn, the macro market system can be understood as two

individual and interacting subsystems. For the non-construction industries, the general performance of the business world is reflected in the commodity market (9). When the commodity market is in prosperity, more investors are rushing to invest because of the herd behaviour (4) and thus lead to irrational investments (7), boosting the entrepreneur behaviour (6). Such a transmission process finally unbalances the equilibriums between 'short termism' and 'long termism' (11). In the market downturn scenarios, commodity market (9) can cause global sentiments over the future (13) and hence increase the volatility (15), which harms the margins of the construction industry (18).

Because of its adjacency to the commercial world, the industrial sector has a more unstable landscape. Interviewees point out that a lower entry barrier (1) may lead to the influx of new competitors (5) and thus produce redundancies in supply (10). This indicates that existing competitors may face tougher situations (14) and the layout of the industry need to be reshaped (18). On the other hand, current players of this industrial sector may increase their competence (23) by enhancing management capacities, such as education (22), staff retention (3), client awareness (25) and so on.

The interactions between the construction industry and others are also crucial in interviewees' conceptual world. They argue that an improved communication between the industry and its clients can finally lead to smarter procurement processes (24) and an improved margin (26). This is reckoned as mutual beneficial as both sides of a contract can be more efficient (23).

Similar to previous sections, the financial environment of the industrial sector is of great interest to the interviewees. Profitability ((2), (18), and (26)) is the major concern of the participants. Given the success of a company is measured by profitability, efficiency of the company (23) and the volatility in price and cost (15) influences the strategy significantly. Also, business structures, such as diversity (27), are emphasized as key issues because appropriate allocation of assets can help companies go through tough times.

Beyond those four interacting groups of variables, other variables, such as confidence (12), can provide insights into both of the real and simulated models. Therefore, the system

dynamics model for this industrial sector shall include the industry itself, other industries, the interactions between all industries, and the overall financial environment.

